DISCOVERY

Sir Lawrence Bragg (*left*) and his Father

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Britain's Health

AGAG himself could not have walked more delicately than Mr. Willink in his White Paper on "A National Health Service," nor have pursued a middle way of more discreet imprecision when it comes to just those controversial questions in which the public are most interested. The basic principle—that everybody in the country, irrespective of means, age, sex or occupation, shall have equal opportunity to benefit from the best and most up-to-date medical and allied services available—is irreproachable and worthy of the most energetic support by all classes of the community. The insistence on the maintenance of health rather than the cure of disease is an equally sound principle, equally worthy of acclamation.

What will interest most people is how this is to be brought about. First it is the intention of the Government to disturb existing tried organisations as little as possible so that the local administration of the scheme will be in the hands of the local authorities, or more exactly of local authorities grouped so as to ensure the best possible district service having regard to geographical conditions and population distribution. The main object is to weld together existing services into a comprehensive scheme, modifying it and supplementing it as necessary. The Parliamentary responsibility of the scheme will be borne by the Minister, but he will have the technical advice and guidance of a new advisory body representing the medical profession in all its aspects, and to be known as the Central Health Services Council. In addition to this there will be another executive body composed mainly of members of the profession, and to be known as the Central Medical Board, which shall be the employer body with whom the practitioner who joins the new service enters into his contract of enployment.

Throughout the country each of the new combined local authorities charged with the task of running the scheme within its own geographical province will have the duty of preparing a plan for the area for hospitals, clinics and other services. In each area also there will be a Local Health Services Council, fulfilling the same functions of technical advice vis-à-vis the local authority as the Central body does to the Ministry.

The local authority in making its plan will have to assess the needs of the area and provide full hospital and consultant services, partly on its own initiative and partly by agreement with existing voluntary hospitals. All hospitals of whatever kind will have to conform to national standards of employment of their staffs, and there will be provision for inspection of hospitals. The consultants associated with these hospitals are to be on a salaried basis, either whole time or part time at rates to be agreed later.

The general public is naturally most interested in the future status of the general practitioner. Steps are to be taken to secure the best possible geographical distribution of medical men in the light of the needs of each area. The general practitioner can operate either as an individual, normally on a capitation basis of the number of patients for whom he is responsible, or as a salaried member of a group of doctors working at a health centre. The arrangements for recruitment to the service are that normally a young doctor shall serve as an assistant for a short period, before taking up a practice of his own or joining a health centre. Permission to acquire a practice in an area already adequately served may be refused, and compensation may be paid to the doctor vacating such a practice when its sale is prevented in this way. Compensation will also be paid when a doctor transfers to a health centre as a salaried member, or when his practice decreases in value as the result of the operation of the scheme. However, the question of the sale and purchase of public practices will remain until further discussion with the profession has taken place. For the doctor the advantage of working at a health centre will be a shortening of hours, the provision of regular holidays, and the provision of a superannuation scheme.

For the patient the service will be free, except perhaps for partial payment for certain appliances, and the cost will be met partly out of rates by the local authority and partly out of the Exchequer. At a health centre under normal circumstances the whole family (not only its insured head) can receive consultation and treatment by appointment

with his selected medical attendant, and in emergency by another member of the staff who happens to be on duty at the time. In general the child welfare schemes will fall under the care of the educational authorities as determined by the new Education Bill.

So far the scheme strikes one as eminently rational and designed to secure a first-class service to the community. It treats the profession with very considerable solicitude, providing for compensation for monetary loss, advantages in the way of conditions of work and of superannuation, and it provides both a free choice of doctor and a discretion for the medical man by not compelling him to join the service. These are the important points to note. Private practice will not be abolished, the voluntary hospitals will not be abolished, and there is very considerable freedom in the preparation of schemes for the local operation of the service. It seems, in fact, that there is little more for the profession to do than to keep its own house in order and provide, as it has done in the past, new proofs of its devotion to the public welfare.

However, there are several points worthy of comment. On the questions of the transfer of practices, on the remuneration of consultants, and on the working of the voluntary hospitals a certain vagueness is noticeable in the White Paper. What the public is interested in is how these things will work out in practice. They will want to know whether the retention of private practice will mean that there will still exist a distinction—more or less subtle—between the first-class citizen, or private patient, and the second-class citizen panel patient, or his new equivalent. They will want to know whether this is going to invalidate the principle of the universal equally available medical service. They will probably also feel some doubt as to the wisdom of grafting the charitable machinery of the voluntary hospitals onto a State service. The public will certainly be sympathetic to the needs of the medical man. They will recognise that local authorities, as at present constituted, are unequal in their virtues as employers, and will want to see those inequalities redressed. On the other hand it is certainly true that they view with a certain suspicion some of the protestations of the older and more influential members of medical organisations, that any form of State service will be detrimental to his—the patient's—interest. Viewing the present *de facto* lack of free choice of doctor, the public rightly or wrongly has come to regard the insistence on this point as a reason for opposing any form of State service, with the suspicion that the objection is disingenuous and is based not on the patient's interest but on the interest of a rather small section of the medical profession. It remains to be seen whether these suspicions are well-founded, but that they exist there can be no doubt.

There is a good deal in the White Paper, in tone rather than factual statement, which will suggest to the reader that there has been some yielding to this point of view. The sentence on page 26 which states that "the practice of medicine is an individual and personal art, impatient of regimentation" is just the food for such reflections. Even taking into account the difficulties and circumstances which the medical profession faces, surely the contrast of the word "individual" and "regimentation" must seem a fairly frank piece of special pleading.

The Minister must hardly be surprised if the public accepts the principles of this White Paper with enthusiasm and its proposed realisation with caution. Too many questions are left unsettled. Too much will remain unknown until the policy of the Ministry is fully unfolded: will, for example, the policy be directed towards the strengthening of the voluntary hospitals or to their replacement? No one can tell until it is seen how the Minister uses the extensive powers which will be left to him. There is, in addition, far too much of a lesson to be drawn from the historical appendix. The present report is too much on all fours with the unrealised promises which marked the end of the last war to be received with optimism. What is certain is that the public will press for more than is promised in the present document.

Physics and Mathematics

It is the object of these monthly notes to provide for the non-specialist some interpretation of the significance of the most recent advances in science. This is comparatively easy to do in such fields as, for example, medicine or agriculture or botany, or the biological sciences generally. Ways of diagnosing or curing disease, ways of increasing the yield of crops or of protecting them from pests, ways of breeding new plants, are all matters of clear interest and obvious practical importance. All that needs to be done in such cases is to prune away from accounts of published work those sections (although they may be very important ones) which are of specialist interest only, and to amplify obscure points.

However, if the non-specialist were to wander at random round a scientific library, taking down volumes of journals from the shelves, he would speedily find that a large proportion of them were incomprehensible to him because they were largely written in mathematical symbolism. This would apply to all the mathematical journals, to most of the journals on physics, and to a much smaller proportion of the biological journals. The chemical journals would present a rather different problem, for although their mathematical content is comparatively small, the special language of chemical symbolism, with which we cannot be concerned at the moment, would be almost as unintelligible as the mathematics, although in a different way.

It is probably impossible to give in any single case a detailed interpretation of scientific work based on mathematical analysis, but it is possible to give some general notion of the status of mathematics, both as it were in its own right and as a tool for physical investigation.

First let us consider applied mathematics, which means the technique of describing in numerical terms some physical situation, such as for example the behaviour of a pendulum, or the motion of an aircraft, or the vibration of a bridge. Now there are many features of all of these problems which the investigator may regard as irrelevant. For instance, it does not matter to him whether the pendulum is green or blue in colour, but it will be important, at any rate for accurate investigations, that the pendulum is in say North Wales or Kent, for the force of gravity, which plays a part in the motion of the pendulum, varies from place to place on the earth's surface. On the other hand, it will not matter to the bridge designer if there are small variations in the gravitational attraction at different places. His interest in geography may be solely that of

temperature, which will expand the bridge members to a greater or less degree. Again the bridge designer will not be much interested in the altitude of the place where the bridge is to be put, whereas the aircraft designer will be very closely concerned with altitude, for this affects the density of the air in which the aircraft must fly.

Thus even when we take into account these more complex factors we are not concerned with all the differences which distinguish one place from another. We are only concerned with special sorts of differences which can readily be expressed by numbers—the value of the acceleration due to gravity, the diurnal range of temperature, the density of the air, and so on.

The mathematician dealing with these problems thus selects certain very limited conditions, preferably ones which can be described by numbers, which he thinks will affect the results of his calculations. The results themselves, even though this may not be explicitly stated, then express statements of the following character: "If I have taken into account all the factors which are relevant to my calculation, if I have used the right sort of mathematics, and if I have made no mistake in working, then the structure I am considering will behave in the following way."

The non-specialist is often very impressed by results which are the outcome of complicated mathematical calculations. He may use such phrases as "mathematical accuracy" and tend to regard anything stated in mathematical terms as a sort of gospel. This is not so. Mathematics is really a very condensed sort of language which could if necessary be written out at length, although only at the cost of a prohibitive prolixity. It is just as easy to talk nonsense in mathematical terms as it is in any other language; in fact easier, since there are far more ways of going wrong. The easiest way of going wrong is by making a frank mistake in working, that is by writing down a line in a calculation which is not the logical consequence of what has been said before. In published mathematical work this only happens very rarely, since all papers are written with great care and are re-examined by referees before publication.

However, a form of error which is much more common is the exclusion of a relevant factor or its wrong assessment. We have already noted that in a mathematical calculation, each statement is the logical consequence of preceding ones. What this implies is that in the process of working, nothing new is introduced. Very many of the great theorems of mathematical physics appear very trite when expressed in simple language. For example, one forbidding looking equation in the theory of the flow of liquids (hydrodynamics, as it is known technically) simply says that water is neither created nor destroyed during flow. This equation of continuity, as it is called, says nothing that even a non-scientist could not have thought of, but by mathematical methods it is possible to deduce from this apparently obvious premise consequences which are very surprising. In such a chain of deduction nothing new is introduced. If the chain is followed through correctly the results will be true if the premise is true. If the premise is wrong, even in a very small degree, error will be introduced which may be magnified many times when the end of the chain is reached.

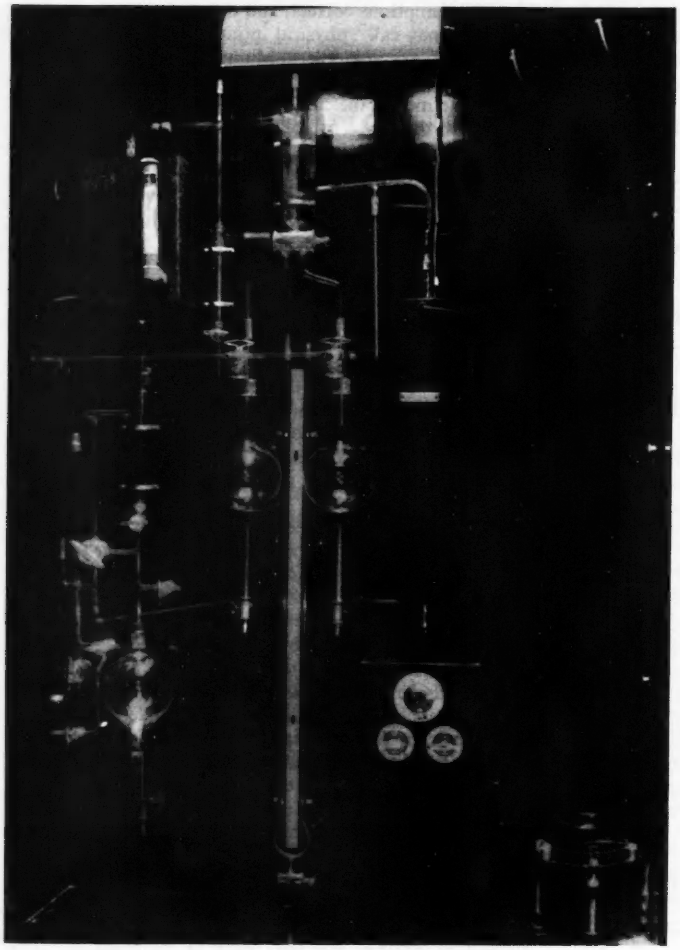
Because of this fact it is most essential to get the fundamental assumptions correct, and this depends on a quality which we may call "physical intuition". Some scientists, such as for example Clerk Maxwell, who predicted the existence of radio waves, have possessed it to a superlative degree. It means the ability to assess which factors are relevant to the problem in hand, and those which may be discarded. This is often a matter of very great difficulty, for the relative importance of factors may change. For example, in considering the motion of a projectile through the air we may legitimately neglect the influence of the sunlight which falls upon it, whereas in considering the motion of atoms and electrons the influence of light may predominate over all others. Thus in the change from large to small the factors relevant to the calculation have likewise changed.

So in applied mathematics we come to two conclusions. One is that the results of the mathematical manipulations will express no more than was put in at the beginning by the calculator himself. The second is that the idea of mathematical accuracy only exists in so far as there has been a correct assessment of the physical factors controlling the situation.

Now what of pure mathematics? One approach to this is to regard it solely as the means of providing tools for the applied mathematician. The applied mathematician may, for example, set up equations which he believes are a correct description of some physical situation, and then find to his chagrin that he cannot solve them. The pure mathematician may be able to help him if he has made a study of all equations of the same type even without regard to their possible application. For example, the applied mathematician may set up an equation to describe the motion of a pendulum, but unless he has a knowledge of algebra and of what are called differential equations he will not be able to solve the problem. The equation of continuity in hydrodynamics which we have referred to already is another example. The applied mathematician may be able to set it up for the case in which he is interested, but unable to solve it without a knowledge of the general behaviour of such equations. Clearly there is no sharp distinction between the two sorts of mathematics. The pure mathematician and the applied mathematician may be one and the same person. Even if they are distinct, each will have a good knowledge of some parts of the other's field of interest. On the whole, pure mathematicians have tended to study the sorts of mathematics which applied mathematicians are likely to find useful, but this is by no means always the case. The pure mathematician will be interested in large general classes of problem quite without regard to possible diverse applications. One such problem of a very simple sort was for example the solution of quadratic equations. General rules can be formulated for the solution of such equations which apply, whether they are needed for application in physics, chemistry, or even biology. The pure mathematician is in fact constantly storing up new weapons in the armoury of mathematics which may at any time be taken out and used in applications. Some of the most unlikely systems of pure mathematical knowledge developed in this way have turned out to be of immense practical value. They include, for example, the geometry of four or more dimensions, the study of numbers which do not obey the commutative law of multiplication, and many others. This second example

means simply a new kind of arithmetic in which A times B is not equal to B times A. Starting from this apparently crazy assumption, consequences have been derived and theorems proved which turn out to be well adapted to the description of many quite ordinary phenomena of the world around us.

This leads to one last point which may be noted about pure mathematics. As in applied mathematics, we start from a series of assumptions, but now we do not try to make them correspond to "reality" or to a given physical situation. All we are concerned with is to make a set of assumptions which are self-consistent, that is assumptions which do not fight among themselves and contradict each other. From these assumptions we can deduce consequences which will be true if the premises are true. They may be quite useless in the sense of having a practical application, but they may throw light on other parts of mathematics, and very often, in quite surprising ways, they turn out to have a quite definite practical value.



Boiling Cold

ASK the housewife how she heats the water for a cup of tea. The reply to such a simple question will be, "I put it on the gas, silly!"

Let us pause a moment and see how the heat from the gas flame eventually produces boiling water. The gas burns at a temperature somewhere between 1700°C. and 1800°C. Water boils at 100°C., so that between the flame and the water there is somewhere a very large drop in temperature. The flame plays on the outside of the kettle and raises it to a temperature of perhaps something like 250 degrees. The boiling water keeps the temperature of the inside of the kettle down to about 100 degrees, so that the temperature drop occurs in the metal of the kettle. This is what we should have expected, for all the time during the heating process heat is flowing through the bottom of the kettle, and we know that heat flows in the direction of decreasing temperature. To use an analogy, there is a sort of temperature hill or gradient down which the heat flows, and the steeper the gradient, the faster the flow of heat. Thus in fact we are heating the water by *conduction*, which means that we cannot raise the inside of the kettle to a high temperature without raising the outside of the kettle to a still higher one in order to create a temperature gradient down which the heat can flow.

The water in the kettle actually starts to move in a series of water currents as the heating process proceeds, because the water in contact with the kettle bottom is heated first and becoming less dense rises to the surface, being replaced by colder water, which is heated in its turn. However, before this mixing process starts, heat must be flowing into the body of the water by conduction, and the same condition must apply, namely that we cannot heat a more distant part of the water before heating the nearer parts to a higher temperature.

We have noticed that the temperature of the flame is very much higher than the boiling-point of water. This is not a point of much consequence in the heating of water because water is a stable compound which does not decompose before it boils. However, scientists are often interested in solutions of substances which decompose at very low temperatures and which yet may have to be concentrated by evaporation. Some of these substances are biological ones of very great importance, such as for example the sodium salt of penicillin, diphtheria antitoxin serum or insulin. None of these can be subjected to boiling without decomposition, and yet at the same time they have to be concentrated. Now one way of doing this is by reducing the pressure to which the solution is subjected. Water boils at 100 degrees under normal circumstances because only at that temperature do all the mole-

cules of the water acquire sufficient energy to get clear of the liquid. If the water were placed in a flask and the air pressure reduced to a half, the water would boil at 82°C. If it were reduced to one-thirtieth it would boil at about 26°C. It follows then that the boiling-point can be brought down a long way by reducing the pressure, but that some heating will still be necessary unless an inconveniently high vacuum is to be used.

The problem of evaporating such a biological solution is thus to apply heat at a low temperature in such a way that at no point does the temperature exceed the limit set by the temperature at which the substance would decompose. Heating by conduction is ruled out because in order to maintain a large flow of heat a high temperature hill would have to be maintained, which would inevitably bring the liquid into contact with a surface at a temperature above the permitted one. The technique of heating such liquids by radiation has recently been described by Mr. J. Arthur Reavell in a paper read to the Institution of Chemical Engineers.

The method can best be understood if we think of the way in which an electric radiator warms us. The radiator emits a great deal of energy, a very small proportion as visible light, and about 99% as infra-red radiation. This radiation warms us because it falls on our skin and is absorbed. The important point to notice is that it only becomes changed into heat energy at the moment of absorption. A small blackened piece of metal placed in the radiation beam will absorb the radiation and become hot, whereas a piece of silica which does not absorb the radiation very much will hardly become heated at all. We could in fact put a sheet of blackened metal behind a thin piece of silica or other material transparent to infra-red radiation, and discover that the more distant metal became hotter than the infra-red translucent material placed in front of it. We have therefore the possibility of making the more distant object hotter than the nearer one, or in other words we can heat substances which absorb the radiation without bringing them into close contact with a hot surface. We are no longer dependent on a temperature gradient.

Now let us consider what will happen if we place a source of infra-red radiation so that it irradiates a liquid contained in a silica tube. The tube will hardly be heated at all, but the liquid—if it absorbs infra-red radiation appreciably as water does—will be heated in a rather uniform way throughout its mass. The heat will be put in, not so to speak by forcing it in from the outside, but will be generated throughout the volume of the liquid to be heated. This is a very satisfactory way of heating these substances, for it means that at no time does the temperature get above the prescribed limit and the heating is very uniform.

The remaining points to consider are whether enough heat can be introduced in this way to concentrate solutions sufficiently, rapidly and whether the expectation that the process can be carried through without decomposing the sensitive biological substances is borne out in practice.

It turns out that they can. With the pressure reduced to one-thirtieth of normal atmospheric pressure (which as we have seen would reduce the boiling point of water to about 26°C.) evaporation can actually be carried out more rapidly by radiation than by direct heating, and with a retention of activity of the biological substances of at least 80%. The method is likely to be one of considerable importance in the future, and the apparatus (illustrated in the photograph) is likely to become increasingly familiar in biochemical laboratories. The infra-red generator is the large cylinder on the right-hand side. The radiant heat is generated in the outer layer and then passes inwards through two concentric tubes of silica between which a vacuum is maintained so as to eliminate all heating by conduction. The liquid to be evaporated passes upwards through the central tube and the gaseous and liquid products are separated and condensed according to requirements in the glass flasks on the left. The mercury U-tube in the centre shows the degree of vacuum which is being maintained in the whole system in order to bring the boiling-point of the liquids down to the necessary low level.

REFERENCE

Britain's Health: *A National Health Service*, H.M.S.O., February, 1944.

Gluing Spider Threads to Lenses

How a spider was made to spin threads which were afterwards glued to lenses to form graticules, has been told by Mr. Frank Elliott in a broadcast. But the story is worthwhile repeating.

"The spiders were a special sort, with a cross on their backs. We used to bring them back to the factory, feed them, and when we wanted a graticule, we made one of the spiders throw a thread. We had a little frame, with two prongs, rather like a tuning-fork with a handle. To make a spider throw a thread, it was put on to this frame and then breathed on. Spiders don't like being breathed on, and it hopped off the frame and threw out a life-line. One end of the thread stuck to the frame and we wound the frame round and round so that the thread coiled round the prongs with the spider dangling beneath, throwing out more and more thread. We used to starve them for about twenty-four hours first. After they have been starved they throw a much more even thread.

"Sometimes you have to get three or four feet of thread to get an inch of even thickness. We examined the thread under a powerful lens, selected a piece of even thickness and laid it, still on the frame, over a metal diaphragm, putting a tiny dot of wax on it to secure it to one edge. Then we stretched it—that was a ticklish job—and tacked it down with wax on the opposite side, and that's how we made graticules. Afterwards we took the spiders back to the moors to recuperate and breed.

"They still use this method, by the way, for making graticules on very powerful instruments—astronomical telescopes for instance. The average spider's thread is about three-tenths of a thousandth of an inch thick. If we wanted a very fine graticule, we used to split the thread. You do that by brushing the thread up and down with a fine sable brush. This unravels the strands and brushes off those you don't want, leaving one in position on the frame ready to use. It's a tricky job and needs a steady hand and a trained eye. We have still got plenty of spiders' threads on frames in our factory, although we are not using them at present."

Graticule markings are also produced on the glass either by acid fumes through a coating of wax or by the direct photographic method.

FIG. 1—Sir Lawrence (*left*) and his father, the late Sir William Bragg

Sir Lawrence Bragg, F.R.S.

CAVENDISH PROFESSOR OF EXPERIMENTAL PHYSICS, CAMBRIDGE

OF recent months the Dean Inges of the scientific world have been making gloomy capital out of a rift which they allege to exist between the older and the younger scientists. The Chinese have a proverb that says a young man takes after his own generation rather than after his father, and anyone who admits the truth of that proverb will realise that the rumoured rift is no more real than the phantoms of Walpurgis Night. Fortunately there are many senior scientists who picture the future of scientific progress in more cheerful, and I think less fantastic perspective.

Among these is Sir Lawrence Bragg. I doubt very much whether he gives any credence to the idea that a rift exists; indeed I doubt whether the idea of its existence has ever crossed his mind. A few scientists have forgotten their youth. Others, like Sir Lawrence, live in closer harmony with life. As he has said: "The majority [of scientists] after the first decade of their research careers continue to live their scientific lives for the most part through their students. Battening upon students, using their freshness for selfish ends, is of course one of the major scientific crimes, and unhappy is the laboratory which has such a head. But there is a better and more normal side to the picture: the purest pleasure in scientific work is to see the germ of an idea one has planted in a younger man's mind develop in a way and to an extent one could not have achieved or foreseen oneself, and to see him get recognition for his work."

I do not think Sir Lawrence will be offended if he is described as being a chip off the old block. In both temperament and scientific achievement he has so much in common with his father. He takes the same attitude towards the younger scientist as did Sir William, of whom Sir E. V. Appleton has written "The young men of science . . . will long remember his heartening and inspiring visits when the distance between senior and junior magically vanished and both hopes and difficulties were shared." In the course of the work that the Braggs did, both jointly and separately, in the early days of X-ray analysis they shared many common hopes and difficulties, and it was altogether fitting that they should have shared the award of the Nobel Prize for physics in 1915 "for their merits in the study of crystal structure by means of X-rays". In the world of science no other "family partnership" has been so fruitful, with the exception, of course, that of the Curies.

To-day the photographs of "Laue's spots" appear even in the most elementary science textbooks; to-day the facts the Braggs discovered are so well-known that there is a danger of under-estimating their importance. W. T. Astbury's remarks on this point are worth recalling. "If I am asked to convey in a word all that the Braggs in those early days did for crystallography . . . I like to tell this story, based on the fact that nowadays straight crystal analysis runs so smoothly that it has become difficult to believe that there were once birth pangs and growing pains. There was put to me some such question as this: 'Tell me, what was all this business about sodium chloride? From the theory of space-groups and a little common sense the thing could scarcely be anything else but Oĥ. You can work the whole thing out simply from atomic weights, the density and Avogadro's number. What *did* the Braggs do with sodium chloride?' To which I could not help replying 'Oh, they just proved the theory of space-groups, that's all.'"

I wonder if Astbury's questioner ever succeeded in equalling Sir Lawrence's record of a Nobel Prize at the age of 25 and F.R.S. before his 32nd birthday!

Youth in Australia

Lawrence Bragg was born in Adelaide, Australia, on March 31, 1890. His father was then Professor of Physics and Mathematics at Adelaide University. He spent his boyhood and his youth in Australia, receiving his early schooling at St. Peter's College, Adelaide, and then proceeding, at the age of 15, to his father's university where he graduated with honours in mathematics. Chemistry, physics and English literature were the other subjects he studied at the University. It is interesting to note that while he was there he won the English prize for an essay on Hamlet. (This ability in a non-scientific subject later developed into a wide appreciation of matters outside science, which was exhibited recently, for example, in a letter he wrote to *The Times* deploring the war-time cessation of arts courses in the universities—a letter that was at once more forceful and more soundly argued than any contribution to the discussion from arts specialists.)

In 1909 the family returned to England, Sir William Bragg having been appointed to the physics professorship at Leeds University. Lawrence became a member of Trinity College, Cambridge. His first intention was to concentrate on mathematics, but after passing Part I of the Tripos in that subject, he decided to study physics for the second part. In his third year he did some research on ionic mobilities. Among the young students with whom he came into contact in the Cavendish Laboratory—then flourishing under the direction of J. J. Thomson—were G. P. Thomson, E. V. Appleton (with whom Lawrence Bragg was soon to

co-operate in crystallographic research), C. G. Darwin and R. Fowler. Another contemporary was Bohr, whom Lawrence Bragg first met during the time the two of them were attending Jeans's lectures on quantum theory.

Following up Laue's Work

This brings us to the year 1912, when Laue published an account of the diffraction of X-rays by crystals. He described, in the *Proceedings of the Royal Bavarian Academy*, the effects obtained when X-rays are passed through a slip of a crystalline substance such as zincblende. (Readers may care to consult Dr. Lipson's article on "X-Rays and Atoms", DISCOVERY, IV, p. 167: this contains reproductions of early Laue photographs.) This paper caused a great stir among scientists all over the world. In the autumn of 1912, Sir William Bragg showed it to his son, whose interest was immediately aroused. Laue had had the idea that if X-rays were waves like light, it should be possible to measure their frequency and wavelength by means of a diffraction grating. If they were in fact waves, their wavelength should be of the order of a thousand-millionth of a centimetre, and clearly the ordinary optical gratings, with a mere thousand or so lines to the centimetre, would be useless for purposes of wavelength measurement. Laue thought that perhaps the arrangement of atoms within a crystal might provide a grating fine enough to diffract waves of so short a wavelength. The first Laue photographs were taken by placing a photographic plate behind a crystal and projecting a beam of X-rays on to the front face of the crystal. The resulting photograph showed a pattern of spots regularly arranged around a strong central spot (where the primary rays struck it). Laue's explanation of the phenomenon brought in the concept that X-rays of different wavelength were diffracted differently and that these differences accounted for the large number of spots in his photographs.

Sir William Bragg, who had been studying the hit-or-miss way in which electrons are knocked out of atoms by X-rays and γ-rays—a phenomenon not easily to reconcile with the idea that these rays were electro-magnetic waves—inclined to the idea that X-rays were made up of bullet-like particles. A natural enthusiasm for his father's point of view led Lawrence Bragg to attempt to prove that Laue's photographs could be explained on a projectile theory, an explanation that would have had to differ fundamentally from the one offered by Laue who postulated (correctly) that X-rays were a wave-motion and that the spots on his photographs were due to diffraction. During his vacation Lawrence made some unsuccessful experiments to see whether he could get evidence of "X-ray corpuscles" shooting down the avenues between the rows of atoms in the crystal, but on returning to Cambridge he gave further thought to Laue's paper, and convinced himself of the correctness of Laue's conclusion that the effect was one of wave-diffraction.

It was then that he realised a deeper significance of the photographs which Laue had overlooked. Their peculiarities, he saw, were a result, not of the complexity of the radiation as Laue had supposed, but of the pattern—the crystal lattice—on which the atoms were arranged in the crystal. A new vista of crystal structure analysis was opened up. It was to that revelation that Sir Lawrence referred in his recent postscript on the B.B.C. "At the time I was not, as far as I remember, thinking of anything in particular when quite suddenly everything fell into place in my mind just as if I had been told. I remember so vividly that I could point out the exact spot on the Cambridge Backs behind St. John's College where I was walking at the time."

The chemists had already developed certain theories about the manner in which atoms and molecules are arranged within crystals. As early as 1819 Eilhardt Mitscherlich had formulated the fundamental law of isomorphism (compounds with similar molecular structure have similar crystals), and by the end of the 19th century men like Pope and Barlow had produced models to show how they thought the atoms of sodium and chlorine must be packed inside crystals of common salt, for instance. Atoms and molecules were still invisible, but indirectly by means of X-rays, the Braggs were able to give certainly to those theories. At Pope's suggestion Lawrence Bragg investigated such salts as sodium chloride and potassium chloride, and showed that the arrangement of the atoms fitted in with the theories the chemists had built up from a different set of facts.

During this time Sir William Bragg, working at Leeds, had proved conclusively that the diffracted waves which Laue had postulated were definitely X-rays. He also found that different metals, when used to form the anticathode of an X-ray tube, gave different and characteristic X-ray spectra, a discovery which laid the foundation of the modern method whereby elements may be quickly identified by X-ray spectroscopy. Sir William also built the first X-ray spectrometer, in which a crystal face could be set to reflect X-rays at any angle (the reflection being due to sheets of atoms arranged parallel to the crystal face) and the strength of the reflected beam measured in an ionisation chamber. This X-ray spectrometer provided a method of analysing crystal structure that was better than Laue's technique. Thus at first we find father and son working independently from different directions towards what was to prove to be a united solution of their problems.

It was at this stage that the Braggs put all their capital into the family firm, and for the next year the two of them worked apace. "It was a glorious time, when we worked far into every night with new worlds unfolding before us in the silent laboratory . . . . It was like discovering an alluvial gold field with nuggets lying around waiting to be picked up," wrote Sir Lawrence recently in his admirable little booklet, *The History of X-ray Analysis.*

Soldier-Scientist in Last War

Now came the Great War, and both the Braggs left the quietness of their university laboratories for surroundings less familiar and less secluded. Sir William became director of the submarine research branch of the Navy's Board of Research and Invention. Lawrence was commissioned in the Leicestershire Horse Artillery, and after a year's training in England was seconded for special service in France, where he was put in charge of the experimental section made responsible for the development of sound-ranging methods for locating enemy gun positions. His "research team" was a sound-ranging unit operating on Kemmel Hill, just south of Ypres. This place was a vital observation post during the long, weary sojourn of the British troops below the Messines Ridge, and the military activity on that part of the front was a constant reminder to every member of the section of the urgent problems that had to be solved. For a year the results these soldier-scientists obtained were disappointing, the apparatus at their disposal lacking the necessary sensitivity. In 1918, however, the Army was able to adopt a new device which the section had perfected, and this proved an immense improvement. Tucker, the Imperial College physicist, who was then serving as a corporal in the Experimental Sound-Ranging Section, had had the idea of using a hot-wire microphone to pick up the gun sounds, and this microphone solved a major problem, that of obtaining high sensitivity to gun sounds coupled with low sensitivity of ordinary noises. The first rough model was constructed in the field, and it was a momentous day when the results that came through showed that the problem had been solved. It should be noted that the apparatus which registered the sounds picked up had been satisfactory from the first: this was designed by Lucien Bull of the Institute Maray in Paris, and was based on a form of spring galvanometer used for physiological research. For this sound-ranging work Lawrence Bragg received the O.B.E. and the M.C. in 1918, and he left the Army with the rank of major. To the Bragg family, however, the war had brought a great loss, for Lawrence's younger brother Robert had been killed at the Dardanelles.

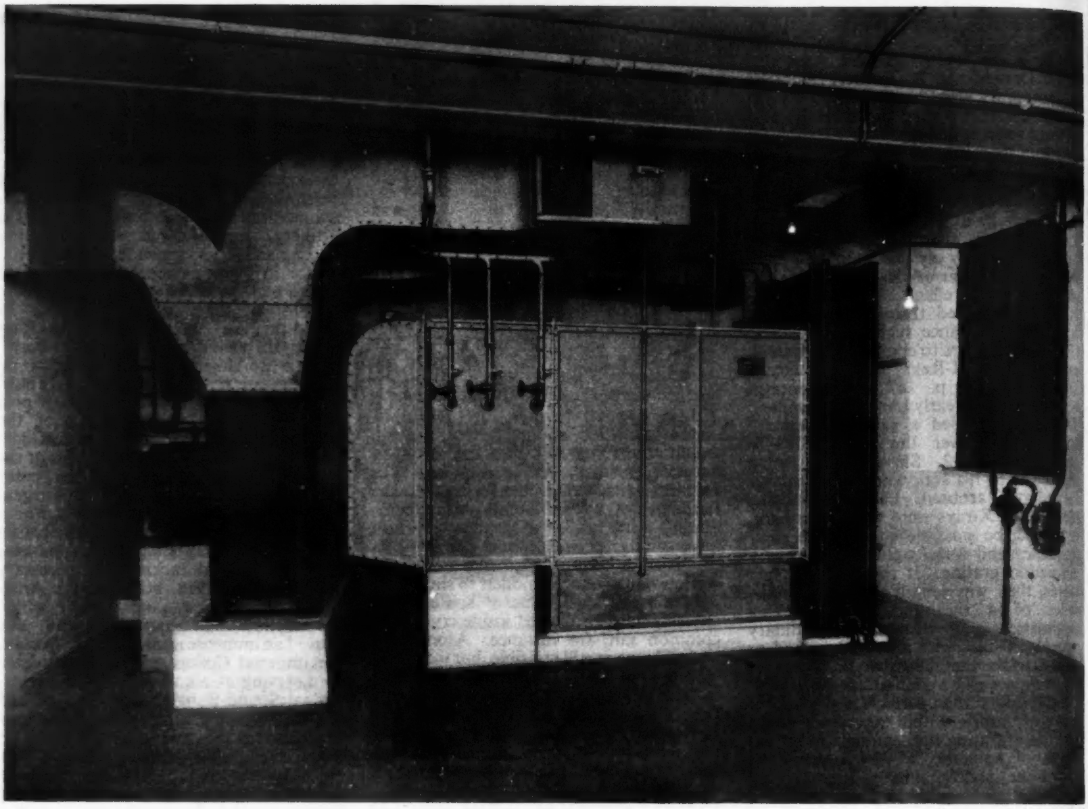
At the end of the war Lawrence resumed for a brief period the lectureship of Trinity College, Cambridge, to which he had been elected in 1914. In 1919 he became Langworthy Professor of Physics at Victoria University, Manchester, where he was to remain until 1937.

He was married in 1921, to Miss Alice Hopkinson. They have two sons and two daughters. His wife's family is well-known in engineering circles: the elder son is following that tradition and is studying engineering at Trinity.

At Home and Abroad

In 1937 he became director of the National Physical Laboratory, but left after a year to succeed the late Lord Rutherford as Cavendish Professor of Experimental Physics at Cambridge.

[*Continued on page* 126



Courtesy of Ozonair Ltd.

FIG. 1.—An Ozonair air-conditioning plant, comprising filter, humidifier, heater, and ozoniser.

Ozone in the Air we Breathe

J. L. EDGAR, B.Sc., Ph.D.

OZONE was discovered by Schönbein in 1840, although its characteristic smell, which is always associated with electrical machines, was noticed over fifty years earlier; Schönbein recognized the fact that this odour was due to a peculiar gas to which he gave the name "ozone", derived from the Greek *ozo*, I smell. It was very soon realised that ozone was simply a modification of oxygen since it could be made by passing pure oxygen through a silent electric discharge, but it was not until 1866 that its formula was definitely established; it was in that year that Soret showed that ozone was an oxide of oxygen, and that whereas the molecule of oxygen contained two atoms of oxygen, the molecule of ozone contained three and its formula was therefore O_3.

Ozone is normally prepared by passing oxygen or air through a space across which is passing a silent electric discharge, and it is therefore obtained as a mixture with other gases; it may be obtained in the pure state by passing the gaseous mixture through a tube immersed in liquid oxygen. The ozone condenses out together with some oxygen, and the latter may then be allowed to evaporate off, leaving the pure ozone behind as a dark violet-black liquid which boils at $-112°C.$ and freezes at the extremely low temperature of $-250°C.$; when the liquid is allowed to evaporate in the absence of other gases it gives a deep blue gas containing 100% ozone.

Ozone is a most highly reactive substance and the pure compound is liable to explode unless it is handled with extreme care; the reason for this is that it is what is termed an endothermic substance and contains a great deal of energy which it wishes to give up at the earliest opportunity, as is the case with all explosives, according to the following equation:

$$2O_3 = 3O_2 + 68{,}000 \text{ calories}$$

This excess energy is put into the gas by means of the silent electric discharge whilst it is being made; it is thus in a meta-stable state and is very ready to go back to the original stable state, oxygen, with the consequent liberation of the energy that has been put into it, the oxygen which is produced being "nascent" and therefore highly reactive.

Ozone as a Bactericide

Owing to the fact that ozone has this surplus of oxygen which it is very ready to give up and the final product of its decomposition (oxygen) is harmless, it finds most important uses and industrial applications as a bactericide; in this respect it behaves in an exactly similar way to hydrogen peroxide which all readers will have used in one form or another. Hydrogen peroxide is merely an oxide of water in exactly the same way as ozone is an oxide of oxygen; its formula is H_2O_2 and it decomposes very easily according to the following equation:

$$2H_2O_2 = 2H_2O + O_2 + 46{,}000 \text{ calories}$$

Thus, its final products are harmless, being water and oxygen, and since it is also an endothermic substance it too is a most effective bactericide. It is not so reactive or so stringent as ozone but it finds much wider applications in surgery, etc., since, being a liquid, it is much easier to handle.

Ozone is used extensively for the purification of atmospheres which are liable to become foul, and for the sterilisation of water; in both cases the very reactive ozone oxidises bacteria and other extraneous substances which may be present, thus rendering them harmless. Over thirty years ago, in 1911, a plant was installed by Ozonair Limited for the purification of the atmosphere of the Central London Underground Railway and this was an unqualified success. In a typical modern pure air ventilation plant the air is drawn by means of a powerful fan through filters and a heating battery; it is washed, filtered again, and then mixed in a mixing chamber by means of the fan with a small amount of ozone. This is drawn in from the "ozonizer" which consists simply of a space across which is passing a silent electric discharge generated by means of a transformer. The purified air is discharged through a special ventilator. Fig. 1 shows a modern installation in use, the air being drawn in through the filters on the right hand side and discharged via ventilators through the large ducts on the left. The concentration of ozone used is one part in four million parts of air and it has been found that the bacterial count of air thus treated shows a great reduction.

Now, although in these very small concentrations ozone undoubtedly has beneficial effects on the air we breathe, in larger concentrations it is poisonous and, owing to its very powerful oxidising properties, has a most irritant action on the mucuous membranes; it has been said that one part in 20,000 is toxic but it will be noted that the concentration of ozone used in modern air sterilisation plants is only one two hundredth part of this. But in view of this it is obvious that an accurate and reliable method of determining ozone in these extremely small concentrations is essential; many such determinations have been carried out in the past but there are reasons to believe that these may be unreliable, as will be described later.

Early Experiments

The presence of ozone in the atmosphere itself was first suspected by Schönbein in 1845 about five years after he had made his original discovery; he found that potassium iodide was slowly oxidised in fresh air, iodine being liberated according to the following equation:

$$2KI + O_3 + H_2O = 2KOH + O_2 + I_2$$

Now the slightest trace of iodine in the presence of starch will lead to the production of a characteristic blue coloration, and Schönbein made use of this in his "ozonometer" which consisted of papers soaked in potassium iodide and starch solution. The use of this simple device indicated interesting variations in the ozone content of the air, and these were deemed to be of such importance by meteorologists and other scientists that regular observations were started in most civilised countries. There are in existence daily records for many decades and the statement that millions of ozone determinations have been carried out is probably not exaggerated; indeed, some observatories still carry out daily observations of the "ozone" content of the atmosphere using this old test-paper method.

Unfortunately, potassium iodide is not a characteristic reagent for ozone alone, but it will show the presence of any oxidising agent, such as oxides of nitrogen or hydrogen peroxide, which may be present; that at least one oxide of nitrogen is frequently present in air has been shown on several occasions and thus it is a true but regrettable fact that the millions of results obtained over the past hundred years which purport to be ozone determinations are actually determinations of the total oxidising agents present in the atmosphere, and the value of these records is therefore extremely doubtful.

Meteorological Importance

These early determinations of so-called ozone in the atmosphere, whilst being unreliable, did indicate most interesting variations in the amount of total oxidising agents present in the atmosphere and when the reliable and accurate photo-electric method of determining atmospheric ozone was developed by G. M. B. Dobson at Oxford, as will be described below, these were confirmed. Dobson and his collaborators showed that large changes in the ozone content of the atmosphere occur within a few days and, what is more important, these changes are closely related to changes in weather conditions; they have shown that the greater part of this ozone is concentrated in a narrow band at a height of between fifteen and twenty miles above the surface of the earth. They have determined the height and the vertical distribution of this layer, and they have attempted to correlate the ozone content of the atmosphere with terrestial magnetic conditions, with geophysical conditions, with the sunspot cycle, and most successfully with meteorological conditions. The vertical distribution of ozone as determined by Meetham at Tromso, Norway, is shown in Fig. 2 in which the approximate heights of some well-known objects are given for comparison; the concentrated band of ozone will be noted and it is a point of interest that the ionised Appleton and Kennelly-Heaviside layers upon which our reception of radio waves depends both lie well above the upper ozone limits—no ionised bands have been observed below it.

The first real attempt at correlation was undertaken in 1926-27; seven stations using the Dobson method were established for the purpose of making ozone measurements and it was found that rough lines of equal ozone content could be drawn on the weather map in exactly the same way as isobars could be drawn for lines of equal pressure.

It was found that the lines of equal ozone distribution travelled across the map more or less in line with the movements of cyclonic depression, and the relation between ozone distribution and meteorological conditions was established. In addition to this it was found that ozone conditions were dependent to a large extent on conditions, particularly of temperature, in the stratosphere. But let it be said here and now that there is no reliable evidence for the statement that there is more ozone in the atmosphere of the coast than in the atmosphere inland; the story of "ozone by the sea" is a myth built up without any substantial evidence.

To-day we live in an age of flight, and flight must—and probably always will—depend on weather conditions—how often have we heard those words "our aircraft were grounded owing to adverse weather conditions" or "on the way to the target our aircraft ran into severe electrical disturbances and storms". The future of trans-ocean and trans-continental flying undoubtedly lies in the stratosphere about which we know very little, and the exact study of atmospheric ozone problems bids fair to further our knowledge. It is in the stratosphere that ozone is produced photo-electrically by the action of the sun's ultra-violet radiation on the oxygen present, and from knowledge of the amount of ozone present and its distribution important information about high-level meteorological conditions may be accurately deduced. It is obvious, therefore, that anything that can further our advancement of knowledge in the field of meteorology and that can help us in the accurate forecasting of weather conditions must assume first-class importance in the field of scientific research.

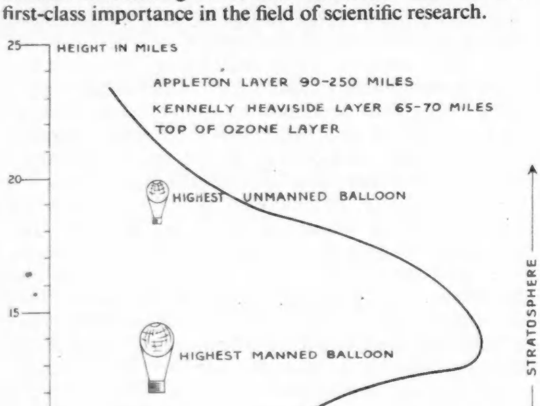
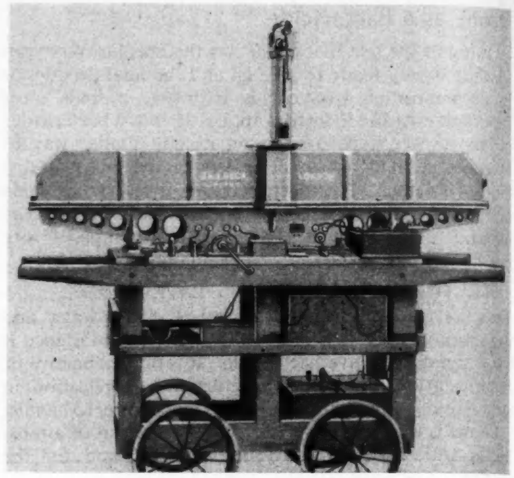


FIG. 2.—Vertical distribution of atmospheric ozone.



Courtesy of R. & J. Beck, Ltd.

FIG. 3.—The Dobson Ozone Spectrometer.

Physical Methods

The first incontestable proof that ozone was present in the atmosphere was due to the spectroscopists. One of the most characteristic physical properties of ozone is that it exhibits a broad absorption band in the far ultra-violet region of the spectrum between 2,500 and 2,900°A. This means that if ultra-violet light is passed through a layer of air which contains some ozone, then a broad band of light is cut out and will not pass through, and it has been shown that very small concentrations of ozone are quite enough to have this effect; it may be mentioned in passing that if it were not for this property, life as we know it on this earth would not be possible. Ultra-violet light is a very powerful source of energy and in a short while burns anything it may fall upon, as those who have sat in the hot sunshine for too long a period know to their cost; now in the upper atmosphere there is a layer of ozone, as will be described later. The sun is a most powerful radiator of ultra-violet light, but before its radiations strike the earth they pass through this band of ozone and all, or nearly all, of the ultra-violet light is absorbed and removed; the sun's rays are thus rendered harmless and we are able to live and bask in the sunshine without any deleterious effects.

Although, as we have said above, determinations of the "ozone" content of the air have been made since 1845, the presence of the gas in our atmosphere was not conclusively proven until over seventy years later—in 1918, to be exact; A. Fowler and R. J. Strutt, two of our most famous physicists, were examining the spectrum of the bright star Sirius, when they found an absorption band in the far ultra-violet which could be due to nothing else but ozone. They also showed the presence of this absorption band in the spectrum of the sun and they were the first actually to photograph it and ascribe it to the presence of ozone in our own atmosphere. These experiments have been

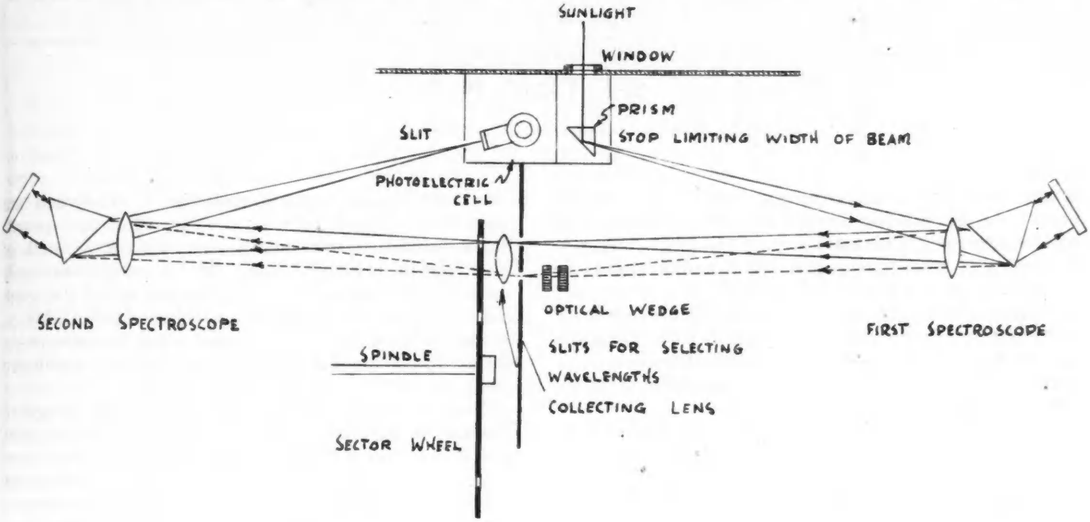


FIG. 4.—Optical system of the Dobson Ozone Spectrometer.

confirmed on many occasions, and they formed the basis upon which Dobson developed his work.

The method used by Dobson is a photo-electric one and his ozone spectrometer which was first described in 1931 has now become a standard piece of equipment. (Fig. 3.) The principle of the instrument is very simple; the relative intensity of the light of two wave-lengths in the ultra-violet region of the sun's spectrum is measured by photo-electric means, the wavelengths being so chosen that whilst one is strongly absorbed by ozone the other is absorbed only a very little. From this single observation and a simple calculation the amount of ozone present can be calculated, the whole operation taking about ten minutes.

The optical system which is employed in this instrument is shown in Fig. 4. Light enters through the window at the top of the instrument and a spectrum is formed by the first spectroscope. The light of the two wavelengths used is picked out of this spectrum by two slits and is then brought by means of a second spectroscope which gets rid of unwanted light to a focus on another slit behind which is placed a photo-electric cell. A rotating shutter, or sector wheel, allows the two wave-lengths to fall on the cell alternately. The current from this cell is amplified to a suitable magnitude. If there is any ozone present at all one of the wavelengths will have been partially absorbed, and so the current produced by the light of the two wave-lengths will therefore not be equal, and the galvanometer which is in the rectified circuit will show a deflection; but if the two rays should produce exactly the same current in the photo-electric cell there will be no flow of current and therefore no deflection. To use the instrument all that has to be done is to reduce the intensity of one of the wavelengths by a known amount; this is done by what is known as an optical wedge, which is simply an optical device by which the transmission can be varied. From the position of the wedge the amount of ozone can easily be calculated.

All of the work so far described measured the amount of ozone in a vertical layer of the atmosphere, and the presence of ozone at ground level had yet to be proved. This was a much more difficult problem because the amount of ozone present at ground level was known to be only about one hundredth of that in the upper air, if it was present at all. Many chemical methods were, of course, in use, but these were all open to the old objection that they were not characteristic for ozone.

In 1918 Strutt attempted to show the presence of ozone by photographing the ultra-violet spectrum of a mercury lamp situated four miles from his spectroscope; the technical difficulties of such an experiment were obviously very great and it is not to be wondered that these first attempts were unsuccessful. It was not until 1931 that success was achieved using this same method; in that year photographs were published, almost simultaneously, in both Germany and France by men who were working independently, and these showed most beautifully the characteristic absorption band of ozone in the spectrum of quartz ultra-violet lamps photographed at a distance of from two to three miles, thus proving conclusively for the first time the presence of ozone in the atmosphere at ground level; this work has since been confirmed on several occasions, but recently there has been evolved a very much simpler chemico-physical method which is capable of giving accurate results not only for the ozone, but also for the nitrogen peroxide content of the atmosphere at ground level.

Recent Chemical Methods

The physicists have shown that, on an average, the quantity of ozone in the atmosphere at ground level only amounts to about one part in a hundred million parts of air; on various occasions the presence of other oxidising agents such as hydrogen peroxide and formaldehyde has been reported, although this has not been conclusively confirmed, but the presence of oxides of nitrogen in the

Continued on p. 114.

A New Survey for Salt in Chinese Waters

S. F. TANG, Ph.D.

Department of Oceanography, China Institute of Geography, Peipeh, Szechuan

A FIVE-YEAR plan for an oceanographical survey along the coast of Fukien was laid down in 1941 by the Department of Oceanography, China Institute of Geography, Peipeh, Szechuan, in co-operation with the Weather Bureau of Fukien, Yungan, Fukien. The purpose of such a survey is to gain a complete picture, with the help of scientific knowledge, of coastal waters off Fukien. This investigation is expected to be a great help in the development of agriculture and fisheries. It may also be of benefit to the Salt Administration.

According to the plan, work has to be done systematically from south to north, along the coast, and this was started from Tungshan Island during the period from the middle of September to the end of December, 1941.

Workers engaged in the last survey were: Dr. T. Y. Ma (Geology), Dr. S. F. Tang (Oceanography and Fisheries), Mr. Y. Chen (Geography), Mr. K. M. Lin (Physics) and Messrs. T. N. Chen and T. T. Yong (Meteorology). The first three were from the China Institute of Geography, Mr. Lin from the Research Academy of Fukien, Yungan, and the last two workers from the Weather Bureau of Fukien.

During the survey, observations on temperature, colour, transparency, and specific gravity of the sea water at each station were continuously taken for a period of twelve hours. Tides and currents at each point were carefully measured. Specimens of corals, shells, sea animals, seaweeds were comprehensively collected and preserved. Meteorological data were simultaneously taken and a Weather Station was then established at Tungshan city.

Tungshan Island is situated in Lat. 23°32′—45′N. and Long. 117°20′—32′E. and lies off the border between Kwangtung and Fukien Provinces. Like a scorpion, the island has a broad head in the north and a narrow body with the terminal point turned to the right in the south. Its length from north to south is twenty-two miles, and its width from east to west is eighteen miles. A channel separates the northern part of the island from the mainland and connects Tungshan Harbour on the east with Chaoan Bay on the west. Tungshan Harbour is a fishery port, and Chaoan Bay is of importance for its salt-works. Fishing and salt-making enrich the islanders much more than the rice fields do the farmers on the mainland, though the lack of fresh water deprives the islanders of farming. As the result of cruel warfare at sea, offshore fisheries have practically disappeared. On the other hand, salt manufacture, because of the encouragement given by the Central Government and the increase of salterns and labourers, has been tremendously developed during the last five years.

It is to be noted that Tungshan is an important fishery centre in Fukien Province, and Tungshan Harbour is a very useful port along the south-west coast of China. The most famous fishery industries in Tungshan are shark's fins, and dried fries or Ting Chu, little pearls. Sharks are fished with lines in winter far off the south of the island to the Brother isles. Sea fries are conveniently hauled up in summer from the shoal waters of the south coast of the island. In addition to those catching fisheries, Tungshan Harbour will be an ideal place for fish-culture, since it has so many rocky isles which are well distributed along the middle line towards the south.

Those who navigate these waters know that Tungshan Harbour is mid-way between the Amoy-Swatow sea route, and affords merchantmen and fishing vessels a very convenient shelter during the typhoon season. However, the nature of the tides and currents in Tungshan Harbour is not yet known, as no observations thereof have ever been taken. Such ignorance may lead to great mistakes in national defence in time of war.

Several scientific papers have been published upon the last survey, both at Chungking and at Yungan by the China Institute of Geography. I presented two scientific papers, the titles of which are "The Tide and Current around Tungshan Island", and "The semi-daily variations of Salinity in Tungshan Waters". A résumé of the conclusions in these two papers follows.

Both the tides and the currents around the Tungshan Islands are of semi-diurnal type. The salt-content of the waters around the island, especially along the northern part, varies considerably in a day. The greatest range, varying from 23.20% to 31.40%, was recorded in the water of Tungshan Channel, and the periodicity of the variation of Tungshan waters was found to be semi-diurnal. It appeared that around Tungshan Island the variation of salinity follows exactly the movement of the tides: i.e., when the tide rises and the current is inward, the salinity of the water increases; when the tide recedes and the current is outward, the salinity of the water decreases during a period of half-a-day. The salinity of Tungshan waters was found to reach the highest point generally half an hour before water, as the water at the time of high tide has already been covered on the surface by a layer of brackish water which comes down from up-stream.

Considering the Tungshan waters as a whole, the highest salinity recorded was 33·03%, the average was 28·12% and the lowest was 21·92%. The difference of 5% between the highest and the average means that the water of high salinity may produce one-fifth more salt than that of the average salinity which is generally used by the salt-workers of Tungshan Island. The best sea-water for filling up the reservoirs of the salterns around Tungshan Island can, therefore, only be obtained during the three hours to half-an-hour before high water, and the best day for filling up is the day following the new and full moons in each month.

Films for Science

PAUL ROTHA

"MOVIES are a racket," said Groucho Marx over the American radio recently. "Not at all; they are Art with an Idea," replied Orson Welles. Each was right, you will agree, if you look back at the events, personalities and pictures of what must now be about 50 years of films. And because movies are a big-time racket—at least the financing and showing of them is—and are also art with an idea—some movies have ideas if not art—you will understand why they have been so little used for serious purposes.

You must always remember that 99% of all films made since film-making was a practical proposition have had as their main purpose the making of profit by providing mass entertainment. That goes also for newsreels, cartoons and such-like types of non-story films. Just how often has a film-financier, film-producer, a film-distributor or a cinema proprietor stopped to ask himself what social effect such films are having? If you asked these men of business, they would reply "The screen's the place for entertainment; we give the public what it wants." And the queues outside your local Odeon or Ritz or Playhouse or Gaumont confirm his answer.

What chance in all this racket, then, has the movie of serious purpose? How, for example, can this great medium for education be used in the service of Science?

Science for Entertainment

First, let's see what the commercial producers have done with science on the screen; science, that is, in its widest terms and for entertainment only. Hundreds of films have had scenes of medievally-lit laboratories, giant retorts bubbling like witches' cauldrons, flashing electrical devices that will disrupt the universe, rockets to the moon, and secret rays to paralyse a continent. This is adolescent stuff. It may, at times, assume the extravagance of Mr. Well's Korda-esque "Shape of Things to Come" (publicised cost: £400,000). Hollywood is always fond of doctors, as witness the "Dr. Kildare" series. More rarely, a doctor and his work for "humanity" become the central theme as in "Martin Arrowsmith" and "Men in White". Warner Brothers have boldly produced a number of what might be called biographical films, and in the series have included Ehrlich and Louis Pasteur. "Madame Curie" has also recently been completed by M.G.M. Hollywood has produced dozens of short films about popular science, mostly of the "Believe It or Not" kind. British studios haven't even got as far as this: their story departments have yet to get around to hearing of Newton, Priestley or Lister. In fact, it has been left to the British Council to make a start with a Technicolour film of Faraday, about which reports are cautious.

You would have thought that the newsreels would have been quick to catch on to scientific items, but their producers only seem interested when the subject is sensational, as when Professor Piccard ascends to the stratosphere or a speed record is broken. It is all on the level of the "Marvels of Science". One remembers films like "The Mysteries of Life" and "The Secrets of Sex". For years now, the makers of the British series "Secrets of Nature" and "Secrets of Life" have tried to crash the public cinemas, mainly with biological subjects, but even with these Wardour Street has insisted on a smart-alec commentator. Hence the following report from *The Times* special correspondent:

> Moscow, January 6th, 1944.
>
> A number of British instructional films were shown to a representative group of Soviet film workers last night. They were well received, though some bewilderment was caused by the peculiarly facetious style of the commentary. It became necessary to explain to the audience that *in the opinion of the British film distributors* the public are unable to appreciate science unless it is sugared with light badinage. [The italics are mine.]

I only hope that it was also made clear to the Soviet audience that the producers of these films do not always hold the same views with regard to the British public as the Trade renters, but that they are dependent on the latter for a showing of their films in the public cinemas.

The Documentary Film

Film-making, however, hasn't been wholly controlled by the views of the trade renters and exhibitors. The small, but influential, group of documentary film-makers in Britain have encroached on the world of science as they have into economics, sociology, and industry. Because the purpose of the documentary film is so often socially progressive, inevitably its makers have touched applied science and research at many points.

This has been possible because documentary films in Britain, not being box-office in the sense that the revenue derived from their exhibition seldom adds up to their cost of production, have found their finance from sponsorship, either industrial or governmental. Documentary films have not, in the main, been produced for speculative profit, but for reasons of prestige and propaganda. Many such films have been made in the past 15 years in the fields of medicine, agriculture, engineering, and communications. Some have been notably successful. The field of public health has been well supported. We have in this country admirable films on plastic surgery, malaria, chest surgery, rehabilitation, tuberculosis, scabies, blood transfusion, the use of anæsthetics and several on the problems of nutrition. Many of these owe their existence to the Ministry of Information. The technical films of the Shell Film Unit have achieved a world reputation for their brilliant use of the screen as a medium of exposition. "Transfer of Power", "Airscrew," "Hydraulics" and "Distillation" are models in their field.

Excellent as most of these films may be, some of them suffer from one major fault. Too often their makers attempt to satisfy both the professional scientist and the ordinary person, and fail to do either. What money for production has been available has had to serve as many ends as possible. Very rarely has the sponsor given the producer one clear job to do—one specific kind of audience

to satisfy. The result has been that the finished film has both disappointed the professional scientist and baffled the layman. It is neither scientific enough nor simple enough. Some people think that this problem can be solved by making two versions of the same film, but in my experience this does not always work out. The fact is that films can serve a multitude of purposes and it has become essential to decide what purpose before the film is made.

Varieties of Scientific Films

There are obviously many kinds of scientific film that could be listed, but I would mention here only a few first purposes to be served by the Scientific Film. As I see it, there is need for films:

(1) To educate politicians, industrialists, civil servants and others in whose hands lies the authority to make use of science. Many such persons are either scientifically illiterate or obstinately anti-scientific. Judging by recent Hansards and correspondence in the Press, there is great need for such films at the present time. The other day I was discussing with one of our most distinguished scientists the script of a film on a particular scientific subject. While agreeing with me that there was need for such a film from the public's point of view, he also pleaded that a film might be made on the same subject to educate first his own employers in Whitehall. Films are wanted for employers just as much as for employees.

(2) To tell the general public at large something of the real character of scientists and their work. Here there is great scope. These films should spread far and wide the information that scientists possess the knowledge to build a world in which there may be met the human needs for decent living. These films must be simple and clear-thinking, relating science to everyday needs. An example on the international scale could be a film to anticipate and publicise the setting up of an International Resources Organisation as discussed at the British Association meeting on July 25th, 1942. The whole conception and working of such an organisation could be anticipated on the screen for world audiences to see its value to the fulfilment of Peace. Under this heading, I would also include films *about* science—not scientific films—for schools. They should be "background" films with the aim of informing children of the multiple parts played by the scientist and his work in everyday life. They would need a different technique from films about science intended for general adult audiences.

(3) To meet the needs of specialists in many fields who need to know how science affects their work in the public interest. For example, farmers need to know how scientific agricultural research affects their day to day activity. This is obviously a most important field—taking the results of research out to the people who can put them into practise.

(4) To tell scientists themselves specialising in *one* branch what scientists in *other* branches are doing. There is need here for scientists to be able to relate their own work in perspective to that of others. The film can perhaps do things that the scientific paper cannot.

(5) To tell scientists in every branch what their colleagues are doing in the *same* field. Here is need for accurate and careful recording, for the film camera to be used in its fundamental purpose as a recording instrument. I need not amplify its capabilities in this direction.

Then, of course, there is great need for films to relate the individual to his or her world of activity. These are films of industry and organisation. Then again there is need for training and instructional films, both in industry and in the Fighting Services. Great strides have been made in the techniques of such films since the war. An excellent body of technicians is now trained for making such films in the future.

Production Techniques

The film's full range of techniques can serve all these many purposes, from dramatic treatment to meet the ends of persuasion to the simple recording of scientific experiment. Each type needs experiment and discussion. There are two aspects, however, about which I would like to say something in particular.

Firstly, the use of diagrams and animated trickwork in the scientific film. Some of us are familiar with the brilliant work of the Shell films in this respect and the skill of Mr. Francis Rodker. You may also have seen films from the Units run by Mr. Bruce Woolfe and Mr. Larkins, and by Messrs. Science and Diagram films, but I would like to add that we are fortunate in this country to have working here the Isotype Institute, under the direction of Dr. Otto Neurath and his wife. Their work at the Museum of Social Sciences in Vienna and as editors of the International Encyclopædia of Unified Science, and their International Visual Language of Isotype Symbols—these have created world respect. Dr. Neurath is a scientist and an economist who has given many years to evolving an international picture language which interprets science and economics to the man in the street and the child in the school. In Britain he has been given the opportunity for the first time to carry his methods of visual education into the medium of the film. We should be glad that this opportunity has been first afforded him by our Ministry of Information. Dr. Neurath and his staff have a great contribution to make to the use of the film—especially the educational film—not only because of their Isotype technique, but also because of their understanding of the methods to interpret the scientific method to the citizen.

Secondly, I would like to record a suggestion for a Mobile Film Unit to be put at the service of working scientists. It has been my good fortune to be in close touch with many scientists over the last 15 years, and I have noted that many of them need only certain stages in their work to be filmed. Frequently there is no need for film technicians to be in constant attendance during scientific experiments. What happens now is that the scientist himself has to try his hand at being a cinematographer. Sometimes he has remarkable success, but more often he achieves only a half success. I am tired of saying that film-making is a skilled professional job. The film needs of scientists in their laboratories and research stations could be met by a Mobile Film Unit which could be called upon at fairly short notice to film such-and-such a piece of experiment from time to time. The results could be carefully filed and kept until the experiment was complete, and then edited in conjunction with the scientific worker. Such films would satisfy both the scientist and the film-maker. It is possible that such a Mobile Unit might be financed by the Government, or on the other hand it might

be subscribed to by a number of laboratories, research stations and technical schools, which would require its services. It would, I believe, solve many problems related to the internal use of the scientific film.

Films as Records

So far, I have dealt in the main with films specifically depicting scientific work ; but there are many other aspects of cinema that embrace science, especially the social sciences.

The film's basic attribute is to record, which it does with a remarkable degree of fidelity. A very great number of events and people have been recorded on film since the funeral of Queen Victoria. Some have been preserved at such repositories as the Museum of Modern Art Film Library, New York, and the National Archives, Washington, while our own National Film Library has made a start at the job. The official war record films of 1914-1918 are cared for by the Stationery Office, and duplicates from them can be used by commercial producers. Each of the five newsreel companies in Britain has its own indexed library of shots from the past, some of which are available—at a price—to other producers.

As the movie gets older, the storehouse of film shots swells. The problem of fashioning films out of this existing material is one of the most fascinating and one of the most important in the cinema. Dramatically, everything that has been filmed up to yesterday is dead material until it is given life and meaning in the editing room. Here the power of the spoken word is immense. Mute visual scenes can be given almost any meaning and significance by a commentator. "World of Plenty," for example, was made up from hundreds of shots taken at different times in different lands for purposes entirely different from those to which I put them. The great storehouse of "library material"—as it is called in the trade—has unlimited possibilities. A film was once made of Frederick Lewis Allen's famous informal history of the '20's' in the United States—"Only Yesterday"—using material from libraries. March of Time's "The Ramparts We Watch", was another attempt at shaping old material to a new use, while anyone who has seen the current "Why Do We Fight?" series issued by the U.S. Government will appreciate the exciting and limitless scope of this field.

No one seems to have decided yet what will happen to the many millions of feet of film taken since 1939 under official auspices. This includes not only the combat coverage obtained by the Service film units, but also the vast footage shot at the commision of the Ministry of Information on almost every aspect of civilian Britain in war-time. Apart from completed films, of which there must be many hundreds, there are miles of unused footage. It is true to say that no other combatant has filmed itself so thoroughly as Britain. It should be someone's job after the war to compile and edit from this mass of celluloid records of Britain in World War II. Clearly it must be officially sponsored and produced with authority.

Progress in the War

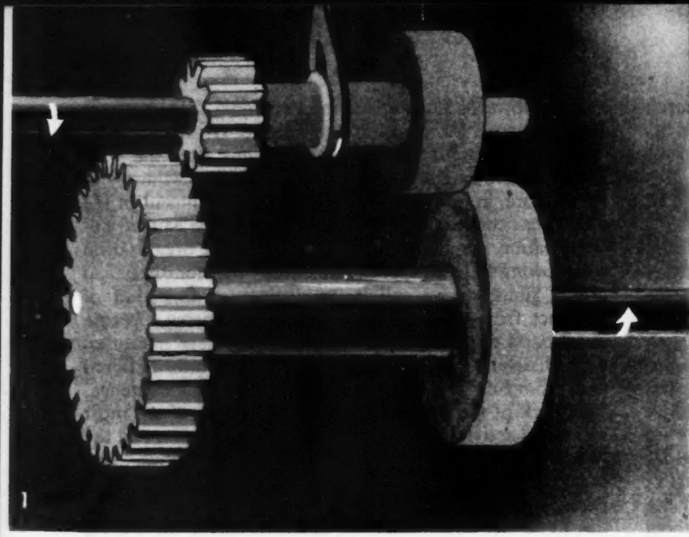
The war has meant a greatly increased use of the film for training and instruction, which is bound to have far-reaching effects after hostilities have ended. There is not space here to speculate on the post-war Government's attitude towards films in the informational field, but it is clear that such Ministries as Agriculture, Health, Labour, Works and Planning cannot discard films after the wide use they have made of them in war-time. The Ministry of Agriculture, in particular, has been most intelligent in the films it has commissioned for instruction. The Ministry of Information has built up a big and efficient organisation for showing films to special audiences—the non-theatrical use of films, as we call it, to distinguish this kind of audience from that attending the public cinema. People in all parts of the country—in factories, village institutes, public halls and the like—have come to accept informational films about daily life as a normal part of their existence. The work of the Central Film Library is one of the most successful activities of the Ministry of Information and the future of the service is of urgent national importance. The potentialities of the whole non-theatrical field are vast. Already we hear of a project of a Civic Cinema in every town and city community. A detailed scheme for a Civic Film Centre has been submitted to the Manchester Council Post-War Reconstruction Committee. The Centre would co-ordinate the film activities of all municipal departments, establish a mobile projector unit to visit schools, organise a library of instructional films, and hold at its cinema daily programmes of educational and general interest films for organised parties of school-children, evening film shows for adults on public administration, sociological problems and the promotion of international understanding, and week-end performances of outstanding artistic, cultural and scientific films not normally seen in public cinemas. This is a fine, progressive project and it is to be hoped that it will come into reality. The Manchester City Council is showing itself very alive to the use of the film for imparting the duties and privileges of citizenship. Other cities might well learn from this initiative. Civics is a great new field for visual education.

The new Education Bill looks as if it will offer many opportunities for the development of the educational film. In the past the Board has pursued a cautious, almost neutral, attitude towards films, but it will no longer be able to do so. We have the right to expect an early statement of policy on films from the Board. Production is not likely to rely solely on the initiative of speculative private enterprise as it has in the past. If the Board equips schools of all kinds—including junior technical schools, people's colleges, residential adult schools—with projectors, it must also concern itself with what films are made to show on those projectors. The distribution of such films must, moreover, be *free*. Production cannot be left to speculative promotion aided by *ad hoc* panels of teachers. Panels never produced good films anyway.

A further indication that Whitehall may continue to be alive to the use of the film after the war is contained in the recently issued Colonial Office report of its Advisory Committee on Education in the Colonies—*Mass Education in African Society* (Colonial No. 186). Here seven pages outline the need for films in the education of backward peoples. Methods of production and distribution are widely discussed, and some kind of control hinted at over commercial productions intended for Colonial Exhibition.

There is likely, also, to be a big development in the use of films for instruction and information by national sponsors, some of which—such as Gas, Oil, and Airways—

Stills from Scien



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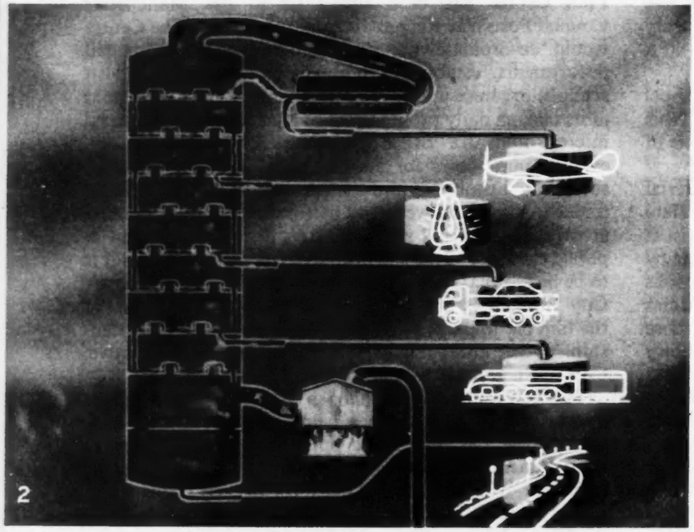

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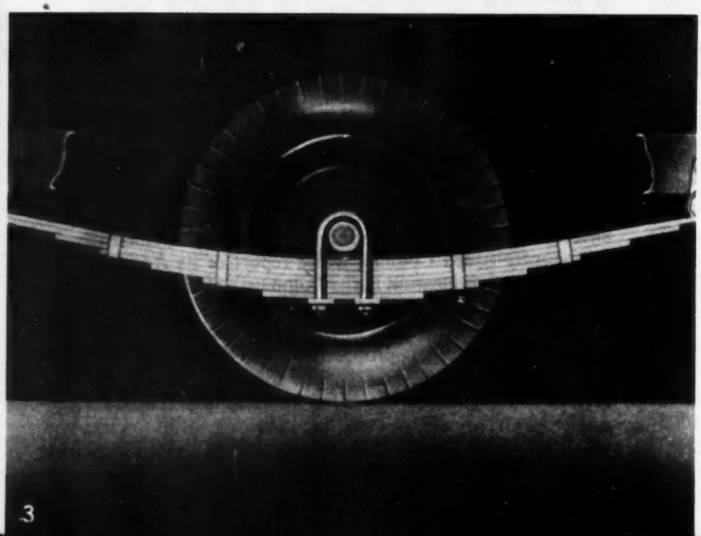

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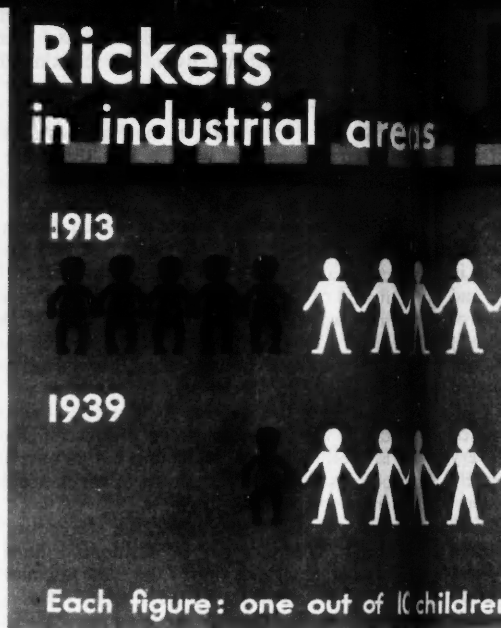
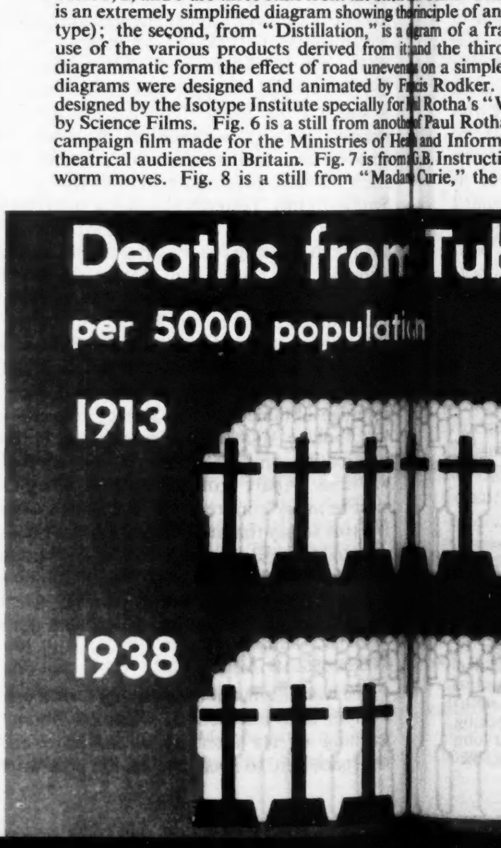
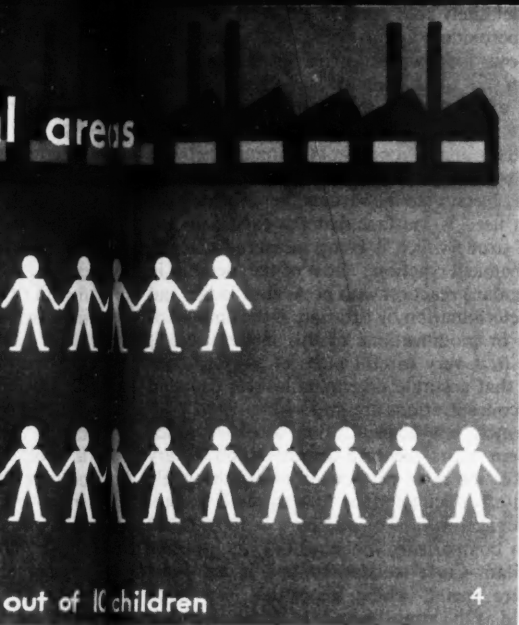


FIGS. 1, 2, and 3 are three stills from the Shell Film Unit. The
is an extremely simplified diagram showing the principle of an
type); the second, from "Distillation," is a diagram of a fra
use of the various products derived from it and the third
diagrammatic form the effect of road unevenness on a simple
diagrams were designed and animated by Francis Rodker.
designed by the Isotype Institute specially for Paul Rotha's "W
by Science Films. Fig. 6 is a still from another Paul Rotha
campaign film made for the Ministries of Health and Inform
theatrical audiences in Britain. Fig. 7 is from G.B. Instructi
worm moves. Fig. 8 is a still from "Madame Curie," the



n Science Films



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from the Shell m Unit. The first, from "Transfer of Power,"
ram showing th rinciple of an automobile gear-box (crash-gate
tillation," is a gram of a fractionating column depicting the
derived from it and the third, from "Springs," illustrates in
of road uneven on a simple type of car suspension. All the
animated by F cis Rodker. Figs. 4 and 5 show two charts
te specially for l Rotha's "World of Plenty," with animation
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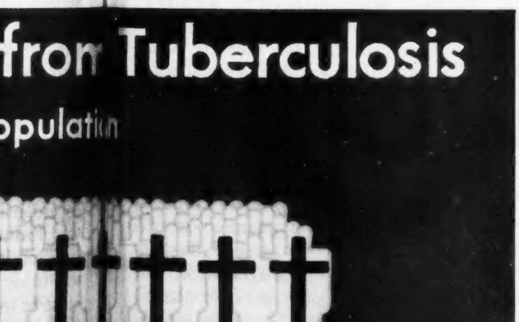
Fig. 7 is from G.B. Instructional film, showing how an earth-
from "Madam Curie," the full-length M.G.M. fiction film.



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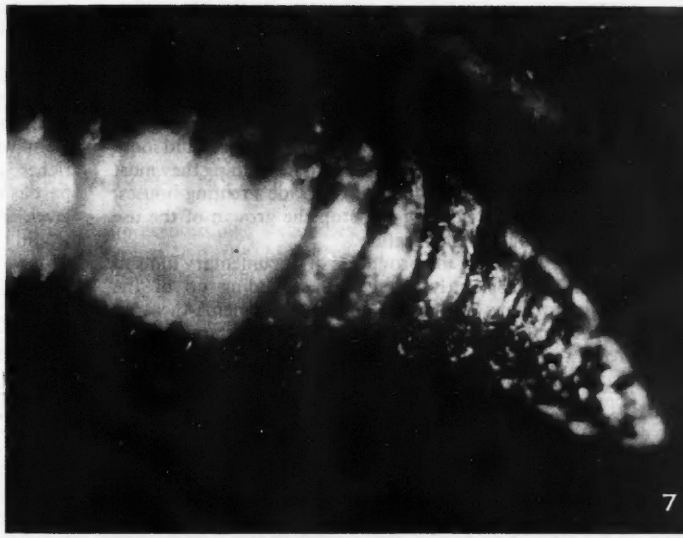
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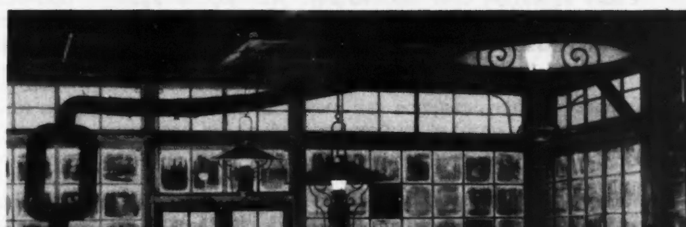
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were active before the war. Newcomers to this field in a serious way are the Cotton Board and I.C.I. The formation of the Scientific Film Association should help in this field to see that the best guidance is given to such films from a scientific as well as from a technical point of view. All scientists who appreciate the potentialities of the screen would do well to support the activities of this new body. It is the first of its kind in the world.

There are signs, then, that the producers of films in the field of science may not for very much longer be compelled to surrender to what, *in the opinion of the film trade*, constitutes public demand. The fact is that in 50 years the movies have grown up and have now become subdivided into many different kinds of film to meet different purposes.

The exhibition field is divided into two audiences—those who go to public cinemas for entertainment and the quickly-growing non-theatrical audience. The need for entertainment films in public cinemas will always continue and their manufacture and exhibition will represent the big profits. But this must in no way prevent and restrict the growing use of the film in other fields. The aims of entertainment and education must be kept separate, except that almost every film teaches something by nature of its very representation of peoples and things and places. It is my belief that many educational films will in time find more and more space on the public cinema screen, but in so doing they must not be sugared at the request of the trade's renting-houses. In the meantime, nothing can stop the growth of the use of the film for visual education.

For 15 years now the producers of documentary films in Britain have patiently pursued the building up of the showing of films outside the commercial cinema-theatres. The information and propaganda needs of the war have brought about a much speedier development than we once visualised. The need now is to see that this great new field is not exploited in the way that entertainment films have been. It is here that the Government, learned societies, professional bodies, and national industries; scientists and educationists; and the public itself, can help.

In such activities as these we may have the answer to Groucho. Need films be a racket in this new world of visual education and information? Are we to allow education to be exploited for private profit? That depends on who makes the films, for whom, and for what.

OZONE IN THE AIR WE BREATHE—*contd. from p.* 107

atmosphere has definitely been established. Measurements of the nitrogen peroxide content of the atmosphere have been carried out over long periods by reliable methods, and it has been shown that the amount of this gas present is of the same order of magnitude as that of ozone; thus, chemical methods which have been used in the past for ozone determinations and which do not distinguish between ozone and other oxidising agents are of doubtful value.

A second grave objection to the various chemical methods which have been used is the fact that the extremely low concentration of ozone which is being measured tends to complicate the chemical reaction; most of the methods in use utilise the standard reaction with potassium iodide and the subsequent determination by titration of the amount of iodine liberated, or modifications of this method, but it has been shown in a very careful piece of work by two French chemists that accurate determinations of ozone in these very small concentrations are impossible.

It is this extremely low concentration of ozone which makes the problem of its accurate determination so very difficult and makes the most perfect technique absolutely essential. It is most difficult for the human mind to comprehend what a concentration of one part in 100,000,000 really means. In comparison, Joachimsthal pitch-blende from which Madam Curie isolated radium is ten times richer in the rare metal, whilst sea water is a tenth part as rich in gold as the atmosphere is in ozone at ground level. A man breathing at the rate of five litres per minute would take about a fortnight to pass a cubic centimetre of ozone through his lungs, whilst the huge Graf Zeppelin whose capacity is over seven million cubic feet would contain only two litres of ozone were it filled with air. Such is the amount of ozone which has to be measured.

The two problems which therefore face the chemist who wishes to carry out atmospheric ozone determinations are to separate the ozone from any other gases which may be present, and to increase the concentration of the ozone to such a degree that titometric determinations by standard analytical methods will give reasonably accurate results; a successful solution of these problems has recently been achieved by the Author of this article working in collaboration with Professor F. A. Paneth of Durham University at the Imperial College of Science and Technology, London (see Journal of the Chemical Society, 1941, pps. 511—527).

(To be continued.)

A Fish Farm in Peru

BRITISH scientists have continually stressed the need for the British Empire to utilise to the full the fishery resources in inland waters and on the coasts of our colonies in order that the deficiency of first-class protein among the natives can be corrected. It is interesting to learn that a fish farm of the type so often advocated is helping Peru to meet war-time food shortage among the fast-growing population in the upper Amazon Valley, the scene of development of rubber and other tropical materials needed for the United Nations' war effort. This fish farm was established three years ago, and according to the President of Peru it has already delivered to the markets of Iquitos more than 22,000 pounds of dried paicha, considered to be the largest fresh-water fish in the world. Specimens of this fish have been recorded up to 15 feet long, and it is regarded commercially as the most valuable food fish in the Amazon Valley. Because it is so valued there is a constant danger of over-fishing, so that steps had to be taken to make sure that stocks did not become depleted. So the paicha reserve, said to be the first fish farm in the Amazon River system, was set up to operate as a fish hatchery, providing small fish for re-stocking rivers, as well as a farm for mature fish. The paicha is a lung fish and comes to the surface about every 15 minutes to breathe.

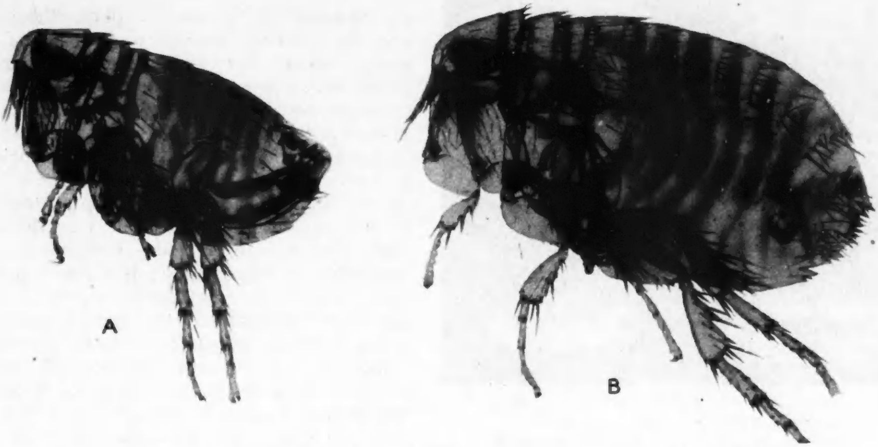

FIG. 1.—The plague flea of the tropics, *Xenopsylla cheopis*, A, male; B, female.

Medical Entomology

By V. B. WIGGLESWORTH, M.D., F.R.S.

MEDICAL entomology was born when Patrick Manson, the "father of tropical medicine", working in Amoy in 1878, discovered that the parasitic worm Filaria, the cause of elephantiasis, is taken up from the blood of man by the mosquito and that this plays the part of intermediary host. The further study of insects as carriers of human disease received a tremendous stimulus when Ronald Ross, inspired by Manson, demonstrated the development of the malaria parasite (which had been discovered by Laveran 15 years earlier) in the Anopheles mosquito.

That was in 1895. The next 10 years were the golden age of discovery in this field. In rapid succession the diverse blood-sucking insects were incriminated. The tiger mosquito as the carrier of yellow fever by Walter Reed and his colleagues in Cuba in 1901 and later as the carrier of dengue; the tsetse fly as the carrier of sleeping sickness by Bruce in Uganda in 1903; the flea as the carrier of plague by various workers in the East about 1898. The tick Ornithodorus was proved to convey the spirochaetes of African relapsing fever in 1904; the human louse to carry the spirochaetes of epidemic relapsing fever in 1907; and the rickettsiae of typhus and trench fever in later years. Certain blood-sucking bugs in South America were proved vectors or carriers of a local type of trypanosomiasis; the sandfly has been incriminated as the vector of five-day fever and of the leishmania infections, oriental sore and kala azar. The house-fly was proved to play a not unimportant part in the spread of dysentery, typhoid and other intestinal infections. In more recent years sporadic forms of typhus have been shown to be caused by rickettsiae normally infecting rodents and other mammals but accidentally conveyed to man when he chances to be bitten by their parasites. Sometimes the rat fleas are concerned; sometimes, as in Rocky Mountain spotted fever, ticks are responsible; sometimes, as in the so-called "scrub typhus" of the Malayan and New Guinea jungles, the little mite Trombicula, first cousin to the troublesome harvest bug of this country, is the carrier.

There are many other less important diseases that are conveyed by insects. Nor can insects be disregarded on their own account. The attacks of mosquitoes and black-flies in the subarctic regions of Canada, Scandinavia, and Russia, even more than in the tropics, make life almost intolerable at certain seasons of the year. The invasion of the living tissues by maggots, the condition called "myiasis", takes many forms depending on the kind of fly and the part of the body concerned. There is the tumbu fly of Africa whose maggot develops in a small boil beneath the skin, and the macaw-worm of the New World tropics which lives in much the same way, except that the adult fly has the remarkable habit of laying its eggs on the bodies of mosquitoes or other flies and allowing these to convey them to the host. These are comparatively innocuous parasites; but in its more destructive forms, for instance when the notorious screw-worm of tropical America is the cause, myiasis constitutes one of the most horrible conditions encountered in medicine. Invasion of the face will lead to the rapid dissolution of the soft and even of the bony parts. Herod the Tetrarch was presumably a victim of myiasis. Scabies or the itch, which is caused by the invasion of the skin by the mite Sarcoptes, is another example of disease caused by the invading parasite itself.

Fleas and Plague

With so many different insects responsible for human disease, the need was soon felt for entomologists who would devote themselves solely to the study of the insects concerned. There was much to be done in their identification

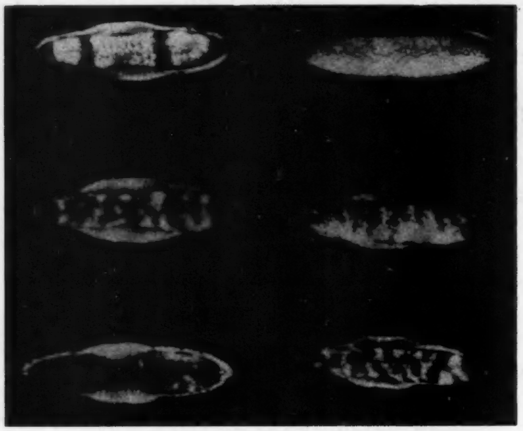

FIG. 2.—Eggs of some of the races of *Anopheles maculipennis*. 1, typicus; 2, messeae; 3, melanoon; 4, sacharovi; 5, labranchiae; 6, atroparvus. (After Hackett and Missiroli).

FIG. 3.—Maps showing the distribution of indigenous malaria in England and Wales. A, during the eighteenth century; B, during the recrudescence in 1917-1918. (After Sinton and Shute.)

and classification; in the description of their life histories and habits, of the intricate mechanisms of their blood-sucking mouth parts and of the manner in which they convey the various pathogenic micro-organisms.

But no sooner were the rough outlines of the transmission of a disease by insects worked out than the epidemiologist began to find new problems for the entomologist to solve. We may take bubonic plague as an example. After a period of uncertainty and controversy the role of the flea in transmitting plague was clearly proved before 1900. Then A. W. Bacot and C. J. Martin demonstrated the mechanism of transmission; how the gizzard of the flea becomes completely blocked by a plug of bacilli so that the thirsty insect cannot pass into its stomach the blood it swallows but regurgitates it into the wound made by its mandibles—carrying with it plague bacilli into the tissues. Now outbreaks of plague occur at the eastern end of the Mediterranean only in the summer. That was readily explained when it was shown that only in the summer does the temperature rise to the level at which the plague flea *Xenopsylla cheopis* (Fig. 1) can flourish and multiply. In parts of India, not only is plague absent in the cold weather, but also in the hot dry weather. That led entomologists to the discovery that the early stages of the flea are highly susceptible to desiccation, so that Xenopsylla can flourish only when the temperature and the atmospheric humidity lie between certain definite limits. From a study of meteorological records it is thus possible to forecast the seasons of the year when plague is liable to break out in a given region.

But the epidemiology of plague in India and Ceylon has shown still further complications. It was noticed that although Xenopsylla was plentiful on the domestic rats throughout Madras and in Ceylon, plague was limited to certain regions, mainly in the hills. It was suggested that there might be undetected differences in the fleas of the various districts. Collections were made and submitted to C. Rothschild, who was the foremost expert on fleas at that time. It was found that there were indeed small but distinct differences between the fleas; that what had been regarded until then as a single species *Xenopsylla cheopis* included a second species which was named *Xenopsylla astia*, and that the lowland regions where plague did not occur were regions in which *X. astia* was the dominant rat flea. These observations were later confirmed in Ceylon, and there it was shown that by applying measures of control against fleas and rodents in the *X. cheopis* areas only, without paying any attention to places where *X. astia* alone was present, it was possible to eliminate plague.

Under experimental conditions both *X. astia* and *X. cheopis* are able to convey plague. There are clearly some subtle differences, perhaps in the behaviour of the flea, such as its readiness to bite man, perhaps in the survival of the infected flea after the death of its rodent host, or in the suitability of the stomach as a culture medium for the plague bacillus, which are sufficient to render *X. cheopis* an efficient vector of plague, *X. astia* a much less efficient vector. These differences still await a satisfactory explanation; but even as the matter stands the case of *X. astia* and *X. cheopis* remains a classic example of the need for the most careful systematic and taxonomic study of disease-carrying insects. Here epidemiology rests ultimately upon the labours of the museum worker or systematist.

Malaria in Europe

The epidemiology of malaria in Europe has presented still more difficult problems. The vast amount of malaria that occurred in south-eastern Europe during the war of 1914-1918, and the widespread epidemics that followed the return of the troops to their homelands and the movements of populations consequent upon the peace treaties, focused attention on malaria in Europe, and the next 20 years saw the unfolding of a new and fascinating chapter in medical entomology. It was at once apparent that the malaria carrier of Europe, *Anopheles maculipennis*, was common everywhere, whereas malaria had a restricted distribution, being absent from the greater part of central and north-western Europe. Museum workers, studying the larvae and the adult mosquitoes, were unable to detect any differences that could be correlated with these facts. But later, workers in the field noticed that there were differences in the structure and patterns of the eggs laid by female mosquitoes from different regions and that there were other differences, in physiology and in habit, associated with these various egg types (Fig. 2). Thus, at the present time, the species *Anopheles maculipennis* is sub-divided into a number of subspecies, races, or varieties. Some of these races, such as labranchiae in North Africa and Sicily, or sacharovi in Palestine, Anatolia and the Balkans, are limited to defined geographical areas and occur alone. Others, such as messeae and atroparvus, are widely distributed and may both be present in the same locality. Some (sacharovi, labranchiae) are carriers of malaria because they have a predilection for sucking the blood of man. This is proved by extracting the blood from the stomachs of females caught wild and testing it against a series of specific precipitating antisera prepared by injecting into different rabbits the blood of man, cow, horse, pig or whatever other host may be likely to serve as a source of food to the mosquito. The relative importance of others (messeae, atroparvus) is determined by more subtle differences in physiology and habit. Thus, with the approach of autumn the females of race messeae cease producing eggs but turn their ingested blood into a store of fat; then they retire into winter quarters in cellars or outhouses and rest without feeding until the spring. The females of race atroparvus likewise cease producing eggs and lay down fat. But their rate of metabolism is less reduced; before long they have used up their store and feed again. This happens throughout the winter; and if such semi-hibernating mosquitoes are wintering in bedrooms they will continue to transmit malaria from September to March. Malaria conveyed by atroparvus in Holland therefore has the character of a "house disease" affecting the members of single houses or groups of houses. The same characteristics were seen in the malaria which appeared among the inhabitants of towns on the Thames estuary in 1917 following the return to those parts of malaria-infected troops (Fig. 3). Malaria was very prevalent in the Eastern Counties of England a century ago. Race atroparvus is still plentiful enough, but the malaria has gone. In England this mosquito spends the winter chiefly in cowsheds and pigsties. Some attribute the disappearance of malaria to changes in agricultural practice and in the housing of man and animals; others suspect some subtle changes in the habits of the mosquitoes.

FIG. 4.—An open grassy-edged drain in a tea garden in Assam. A typical breeding place of *Anopheles minimus*.

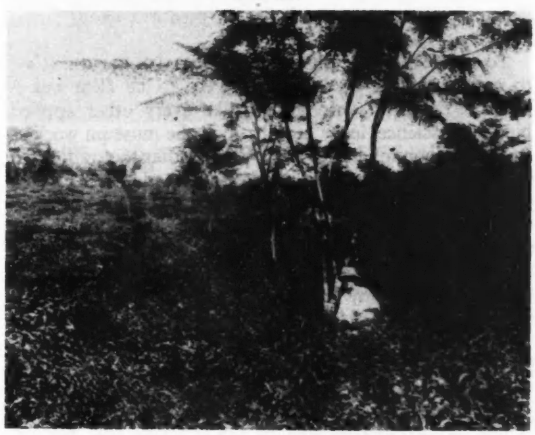

FIG. 5.—A drain in a tea garden in the western Dooars, similar to that in Fig. 4, from which *Anopheles minimus* has been excluded by completely shading it with dense shrubs.

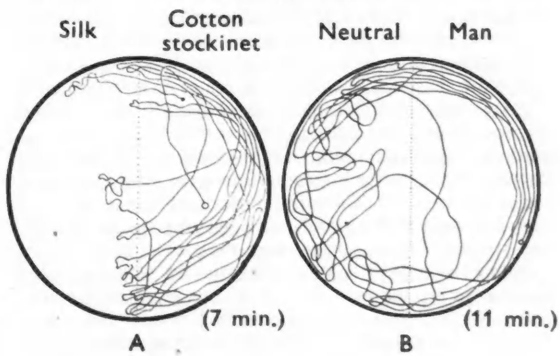

FIG. 6.—The tracks followed by a human louse when placed in an arena with different conditions on the two sides. In A, the floor on one side was of fine silk, that on the other was cotton stockinet. In B, one side had clean cloth, the other had been worn next to the skin for some days.

As invariably happens when practical problems are examined closely, this study of malaria in Europe has produced further questions of great interest. More is probably known about the natural history of *Anopheles maculipennis* than about any other species of insect, and the complexity of what would commonly be regarded as a species has become apparent. Much remains to be done before the status of the so-called "races" can be regarded as settled, but it is already clear that they show many degrees of relationship. Only the atroparvus male has so far been persuaded to mate in small cages. Crossed with females of the other races, varying degrees of infertility are revealed, death supervening at varying points. With messeae most of the eggs are sterile; with sacharovi the larvae die; with typicus sterile adults of both sexes result; with labranchiae all the resulting females are normal but a part only of the males. Indeed some authors describe certain of the "races" as true species. Analogous problems have turned up in other parts of the world. *Anopheles culicifacies* carries malaria in some parts of India but not in others. *A. stephensi* is a carrier in Bombay; but Calcutta, where this mosquito is plentiful enough, has almost no malaria.

To accept the principle of evolution and at the same time to expect specific distinctions always to be clear cut is illogical. Medical entomology, like every other applied biological science, leans heavily upon the museum worker. But it is becoming increasingly evident that the traditional standards of the museum worker are inadequate to deal with the finer distinctions within a species, distinctions which may be of profound biological importance, unless criteria of genetics, behaviour and physiology are also taken into account. Perhaps it is along these lines that the future of taxonomy lies. Then once again systematics will form the hub of the biological sciences.

Insect Ecology and Insect Control

The relation between pure and applied science provides indeed an admirable text around which the present problems of medical entomology may be described. The first task of science is commonly to explain the success of methods used in practice. To reach a rational basis for such empirical results may be a long and difficult process; but once achieved, these results are often found to spring from general principles which admit of wider application and which may lead to a simplification of existing practice.

An excellent example of the workings of the scientific method is seen in Assam and Northern Bengal. The tea gardens in the Assam hills and the Dooars, as well as long stretches of the Burma Road, are among the most malarious regions of the world. The carrying species is *Anopheles minimus*, a mosquito which breeds in open grassy-edged drains and streams (Fig. 4). Faced with the problem of recommending methods of control which the tea planters could employ during the period of economic depression in the early thirties, malariologists devised many ingenious procedures applicable in different localities. One of the most successful of these was to plant suitable shrubs along the margins of the streams so that eventually these ran through a tunnel of dense shade. No larvae are to be found in these shaded streams, and it was supposed that the female mosquito would not lay her eggs in shaded water. But when an experimental study of the ecology and behaviour of *A. minimus* was made it was found that although the female laid her eggs during the night she actually preferred the most densely shaded sites. On the other hand she would not lay in moving water. Indeed, her selection of the grassy margins of streams depends on the fact that she can find there both local shade and still water; and the efficacy of dense shrubs in eliminating breeding is due to the exclusion of marginal vegetation so that flowing water extends right to the edge of the stream. It is possible therefore to exclude the mosquito from the streams either by covering them with dense shade (Fig. 5), or by exposing them to full sunlight and clearing away by hand all the grass along the margins. It will depend on local conditions which method is the more practical.

The tsetse fly presents a similar story. It has long been known that cutting down forest is one of the surest ways of controlling the tsetse fly. But in the drier parts of Africa, for example in Northern Nigeria, clearing of the forest is only too liable to be followed by erosion of the soil and extension of the desert. Now when the physiology of the tsetse fly was closely studied and the limits of temperature and dryness which it can tolerate were defined, it was found that over much of its range the fly was living very near to the borderline, and that it was able to maintain itself only by taking advantage of the cooler and moister pockets in the dense thickets. Thus by cutting away the undergrowth in the thickets, without interfering with the larger trees, it has been found possible to abolish the sites with a favourable "microclimate" and so to exclude the tsetse fly without any risk of erosion.

The Importance of Insect Physiology

Many other examples could be quoted in which the elimination of a dangerous insect can be brought about by some change in agricultural practice or some deliberate alteration in the environment which renders conditions unfavourable for the insect in question. Such methods can be exploited to the full, indeed they may only be suggested, when an intimate study of the physiology of that species has been made.

One of the most important sides of insect physiology from this point of view is that which concerns sensory perceptions and behaviour. Under conditions of active warfare in jungle or in the front-line areas, one of the few measures that can be adopted for the protection of troops from malaria is the use of repellants—substances which on application to the skin will prevent the biting of mosquitoes. Many of the best known materials used for this purpose, such as oil of citronella, are strongly smelling essential oils. But the effectiveness of these repellants bears no relation to the strength or persistence of their odour as judged by the human nose; and some of the most successful of the newer synthetic repellants, many of which are very much more active than the essential oils, are practically odourless to man. Here is a field in which we need to know much more about the perceptions and behaviour of the insect.

Much more is known about the sensory physiology of the human body louse. It is possible to analyse the reactions of the louse to each of the stimuli in the environment in turn by placing it in a small arena in which the two halves differ in a single factor at a time (Fig. 6). As soon as it enters an

unfavourable environment, which lacks a preferred odour of sweat or of other lice, or which is too warm or too cold or contains a repellent odour, the louse immediately turns round and comes back; or, if the unfavourable stimulus is very weak, it merely follows a convoluted course instead of the straight course which it pursues in favourable surroundings. In this way it can readily be shown that the louse prefers darkness, rough materials, a temperature of about 30°C., the smell of clothing soiled by sweat or by the excreta of lice, and so forth. These reactions have been made use of in designing poisoned belts in which lice may be trapped. The reaction to smooth material will explain the observation that silk underclothes are less readily infested with lice; but the protection they afford is not absolute; in the absence of rough material the louse soon settles down quite happily on smooth.

An interesting example of apparently complex behaviour in an insect being explicable as a quite simple reaction is afforded by the tsetse fly. It was noted in parts of Northern Nigeria that normally the tsetse fly *Glossina morsitans* deposits its young at the outskirts of the thickets (Fig. 7). At the hottest season the pupae of the fly cannot survive in these exposed spots; but before that season is reached the fly changes its habits and deposits its pupae in the dense shade of the thicket. This apparent prescience on the part of the fly is readily explicable. If tsetse flies are enclosed in a large cage with one half shaded and the other light, they will always congregate in the illuminated side. But if the temperature is gradually raised a point is reached, at about 40°C., at which their reaction changes and they avoid the light. They will even do this if the experiment is so arranged that the temperature in the shaded half is much greater than in the light half; so great indeed that the flies which enter it are quickly killed.

Control by Insecticides

But it is not always possible simply to upset the balance of nature and rely on the behaviour of the insect in the changed environment working its destruction. Reliance must often be placed upon chemical insecticides. The classic method of poisoning mosquito larvae by applying a film of oil to the surface of the water is still a valuable standby. In recent years an effort has been made to increase the efficiency of oils by studying exactly how they work. A suitable oil must spread over the water surface and form a stable film; it must enter the spiracles or respiratory openings of the larva and creep along the breathing tubes or tracheae; and it must contain materials toxic to the larva. To find an answer to all these demands it has been necessary to carry out extensive studies into the physical chemistry of oils in relation to their spread on water. Much is still obscure, but it is possible now to draw up at least a partial specification for an efficient anti-mosquito oil, a specification which may cut right across the ordinary standards employed in the oil industry but which will provide for spreading pressure, film stability, toxicity.

The killing of the adult insect is likewise a standard method for the control of mosquitoes. It is a method of prime importance at the present time for the prevention of malaria on the war fronts. The mosquitoes are killed by regularly spraying quarters with insecticidal mixtures, usually extracts of pyrethrum in kerosene. The liquids are

FIG. 7.—A typical "breeding place" where tsetse fly deposits its larvae at the margin of a thicket in Northern Nigeria.

atomized in hand spray-guns or power-operated paint sprayers or dispersed in some gas kept liquefied by pressure. In recent years the demand for more efficient sprayers and more active insecticides has led to a detailed study of the factors which influence the performance of an insecticidal spray. There are physical factors such as the size of droplet produced, which in turn is influenced by the spraying pressure, the construction of the nozzle and the physico-chemical properties of the spray mixture. There are the factors also which influence the penetration of the poison through the skin of the insect. Here we are at once in that vast and difficult field in which physical chemists and cellular physiologists are still striving to discover consistent explanations of observed effects.

It is obvious that medical entomology has travelled far indeed. Its roots now penetrate deep into all the basic sciences and its advance in the field of practice is held up at many points by lack of knowledge on fundamental questions. Lip service is often paid to the importance of pure science as an aid to practice. But even the loudest advocates sometimes fail to make out a convincing case. That is because it is rare for the results of research in pure science to have an immediate practical application. It is only when the intervening links are interposed that the connection becomes apparent. It is then seen that the practical measures directed against an insect, for example, depend first upon an accurate recognition of that insect species; then upon a thorough knowledge of its habits. As soon as its habits are closely studied, problems in its physiology arise for solution. These wait upon a knowledge of the physiology of insects in general; and so in turn on general physiology, chemistry and physics.

The Night Sky in May

M. DAVIDSON, D.Sc., F.R.A.S.

The Moon.—Full moon occurs on May 8d. 07h. 28m. U.T., and new moon on May 22d. 06h. 12m. The following conjunctions take place:

May		
20d. 13h.	Mercury in conjunction with the moon,	Mercury 2°N.
24d. 04h.	Saturn ,,	Saturn 2°N.
27d. 01h.	Mars ,,	Mars 1°N.
28d. 10h.	Jupiter ,,	Jupiter 1° S.

The Planets.—Mercury is in inferior conjunction on May 2 and is stationary on May 14. The planet rises about the time of sunrise at the middle of the month and 40 minutes earlier than the sun on May 31. Venus rises shortly before the sun throughout the month and is not favourably placed for observation. Mars in the constellation of Gemini in the early part of the month, moves into Cancer towards the middle of May, and is visible in the early part of the night. The planet sets at 1h. on May 1 and at 23h. 48m. on May 31, and between these dates its distance from the earth increases from 164 to 187 million miles. Jupiter, in the constellation of Leo, sets at 2h. 10m., and 0h. 19m. at the beginning and end of the month. The planet is 480 million miles from the earth on May 1 and the distance increases by 43 million miles on May 31. Saturn, in the constellation of Taurus, sets at 23h. and 21h. 19m. at the beginning and end of May. During the month the distance of the planet from the earth increases from 905 to 930 million miles.

The circle represents the orbit of the earth and the dotted curve that of Halley's Comet. The debris of the comet is spread along its track and the earth encounters it each year in the early part of May, a meteor shower resulting from the collision.

Meteors.—The η Aquarids are active from May 1 to 6, and can be seen only in the morning hours. The radiant of this shower is close to R.A. 22h., Dec. $-2°$. These meteors are caused by the debris of Halley's Comet colliding with the earth. The diagram shows the orbits of this comet and of the earth, and each year the earth encounters the debris twice; in May when the Aquarid meteor shower is active, and from October 18 to 26 when the Orionids appear. There is a little doubt about the latter meteors being due to the debris from Halley's Comet, but it is quite probable that they are caused by this comet. Halley's Comet has retrograde motion, that is, it moves round the sun in a direction opposite to that of the earth, and for this reason when the debris, scattered along the track of the comet's orbit, encounters the earth, the velocity with which the particles rush through the earth's atmosphere is high. The speeds of meteors relative to the earth vary from 10 to 45 miles a second, and when they dash through our atmosphere with such velocities the temperature of the molecules of air is raised, and also that of the meteors, which are volatilized very quickly.

The particles responsible for the flash of light that we see in these cases are very small, in most cases like grains of shot, and a body the size of a pea would appear very bright if it struck the atmosphere. Occasionally the bodies are too large to be completely burnt up, and then fragments of them reach the ground, disruption into a number of pieces generally occurring owing to the enormous pressure of the atmosphere condensed in front of the rapidly moving bodies. Many hundreds of millions of meteors strike the earth's atmosphere every day, but it is comparatively rare for a meteorite (the name given to a meteor which reaches the earth's surface) to be found.

JUNIOR SCIENCE

The Weight of Air

Last month I told you something about the part played by the air in lifting an aeroplane. However, not only air flow but also still air can exert very considerable forces. We are accustomed to think of air as something rather light, and that is quite true if we compare it with, let us say, iron or water. A pint of water weighs a 1000 times as much as a pint of air.

However, there is a lot of air in our atmosphere, and its total weight is quite big. On every square inch of the earth's surface the atmosphere presses with a weight of nearly 15 lb. We do not notice this pressure because all the little spaces in our body—as, for instance, that behind our ear drum which is called the middle ear—are also filled with air of atmospheric pressure. Nature has even provided a tiny connecting tube between this space and the mouth, so that, if for any reason the atmospheric pressure around us changes, the middle ear will always be filled with air of the same pressure. If our ears were not provided with this tube, our ear drums would be blown out when we climbed a high mountain where the atmospheric pressure is much smaller than at sea level.

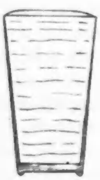

Fig. 1.

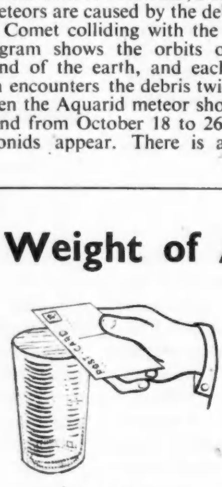

Fig. 2

You can demonstrate this atmospheric pressure by a simple and striking experiment. Fill a tumbler with water until a "head" stands above the rim of the glass (Fig. 1). Then slide a postcard over the rim so that no air bubble remains in the water (Fig. 2). You can now turn the tumbler upside down without the water running out (Fig. 3).

This is the explanation: On one side of the postcard rests the weight of the water in the tumbler and on its other side the weight of the atmosphere. Since the weight of the atmosphere is equal to that of a column of water of more than 30 feet in height, it more than balances the column of water in your tumbler which is only about 4 inches high. K.M.

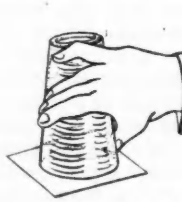

Fig. 3

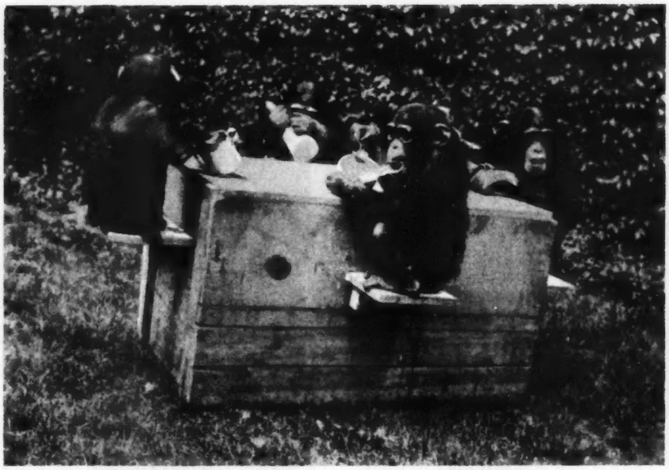

FIG. 1.—A quartet of chimpanzees at dinner.

Chimpanzees: a psycho-biological review

J. GRAY, Sc.D., F.R.S.

MAN as the culminating point of vertebrate evolution is now a familiar and well-established concept; from a primitive aquatic ancestor we can trace our origin through the early terrestrial reptiles and mammals until the final step from the higher primates to man is—from an anatomical point of view—a relatively simple and inevitable step. This strange but well-documented history is recorded with peculiar clarity in the gradually increasing complexity of structure displayed by the vertebrate brain. Our knowledge of comparative brain anatomy is, of course, limited in certain important directions, but it is sufficient to justify the question, "How far can we trace, side by side with ever-increasing anatomical complexity, a corresponding increase in complexity of behaviour pattern?" For a variety of reasons—some good and some bad—biologists have tended to fight shy of this natural aspect of comparative neurology. We know something of the conditions which determine an individualistic type of behaviour in fishes and of the processes of "learning" in rats and a few other mammals; we are, however, a very long way from the possession of a comprehensive comparative picture of vertebrate behaviour. To this difficult and somewhat undisciplined field of biology Dr. Yerkes has made contributions not only of great importance to biology but also of profound interest to human sociology; for many years he has made an intensive study of behaviour of chimpanzees. The aim of his latest book[1] was two-fold—firstly, to present an objective picture of the development of behaviour patterns in an animal very closely related to man; secondly, to consider how far the principles which govern the control of chimpanzee behaviour can be applied with profit towards a solution of apparently specific human problems. To the layman the second objective may appear slightly bizarre if not fantastic, but a study of Dr. Yerkes' work may leave him a wiser but not necessarily a sadder man. "If as servant of science the chimpanzee should help to make clearer and more attractive to mankind ways for the achievement of greater social-mindness, dependability and co-operativeness, how immeasurable our debt to it!"

Servant of Science

As a subject for psychological analysis the chimpanzee differs from the lower mammals in the degree to which its response to environmental change clearly reflects the characteristics of the individual rather than those of the species. Anger, pleasure, elation and melancholy are concepts which alone seem adequate for the description of the animal's condition. Further, the complexity of the "problems" which the animals can "solve" is of an entirely different order to that attainable by any other type of animal. At the same time, it is necessary to bear constantly in mind the danger of confusing a series of imitative and essentially non-purposive acts with something much closely allied to the concept of human intelligence. Nevertheless, it is impossible to avoid the conclusion that the behaviour of the chimpanzee differs from that of man in a quantitative rather than a qualitative nature. This is particularly clear in Dr. Yerkes' picture of the development of the character of individual animals from birth to maturity. For the first year of its life the young chimpanzee is dependent on its mother, after which it gradually acquires complete self-reliance. This and subsequent phases of youth are astonishingly similar to the corres-

[1]*Chimpanzees: a laboratory colony*, by Robert M. Yerkes. Professor of Psychobiology in Yale University (O.U.P., 1943; pp. xvi + 322 + 63 plates and 24 figs.; 33s. 6d.).

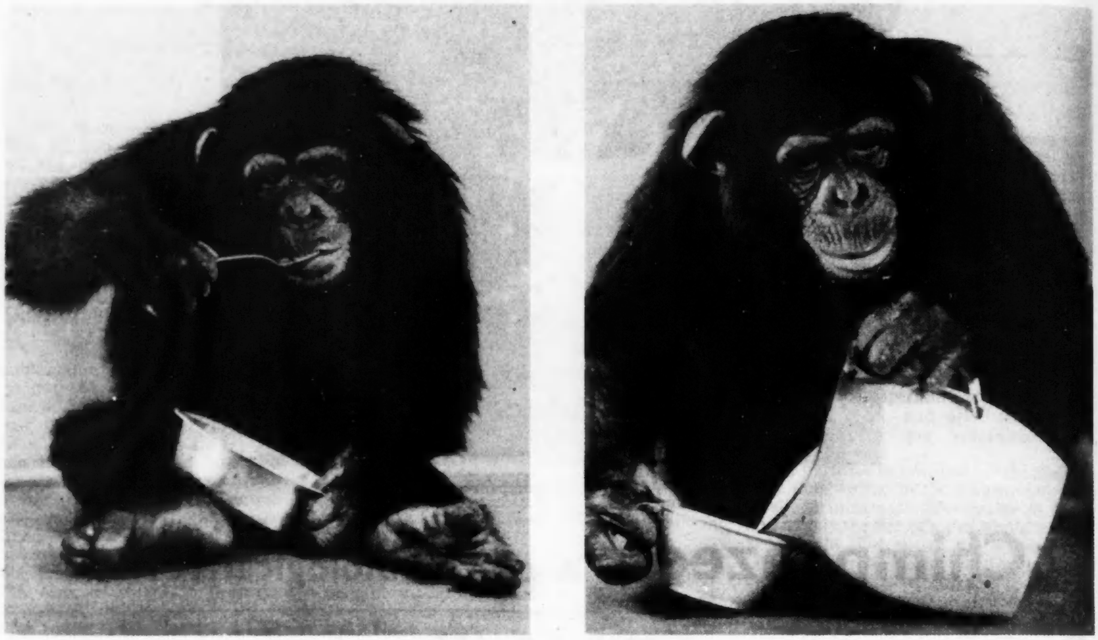

FIG. 2.—The use of human implements.

ponding periods of a healthy and unrepressed human child. "It is eager to play and its playfulness, with its mischievous and humorous turns, exhibits resourcefulness, ingenuity and constructivity." With not infrequent fits of passing temper, the parallel to the human child is obvious. As childhood merges into maturity, impulsiveness and gaiety give way to reserve and moderate quiet; fits of temper become less frequent, and where they persist they are more akin to mature anger. As an adult each chimpanzee appears to display, against a common inheritance of character, individual characteristics which are the result of its own personal experience. The extent to which the common heritage of emotional pattern can be modified by methods under the control of the observer is one of the most fascinating studies in animal psychology.

FIG. 3.—Pairs of boxes used for serial learning tests. The animal was placed on the stool at the centre of the circle when the food was placed in one number of each pair of boxes.

So far a direct study of the more emotional types of behaviour has proved extremely difficult, and, for time being, it is useful to consider the factors which appear to influence the rate at which individual animals learn to perform a relatively complicated series of apparently purposive acts. From a wide and varied series of observations, Dr. Yerkes has shown that four major factors are operative. Firstly, the degree of complexity of the "problem" presented to the animal: the harder the problem the longer is the time required for its "solution"; the chimpanzee may not solve a simple problem more quickly than a rat, but it can solve a problem whose difficulty is far beyond the powers of the rodent or dog. Secondly, the time required to solve a "problem" depends on the degree to which the attention of the animal can be focussed on the problem, and be prevented from straying to other features of its immediate environment; the concentration of the subject depends to a marked degree on the degree of "sympathetic" co-operation established between the "teacher" and the "learner". Thirdly, the time required for successful learning depends very definitely on the presence or absence of an adequate reward, the nature of the reward varying with particular individuals and circumstances. It is significant that the corresponding influence of "punishment" eliminates the gain due to co-operative action between observer and subject. Fourthly, the rate of successful learning depends to a variable extent on the opportunity presented to the animal of imitating other animals or man. By careful control of all these factors chimpanzees learn to perform a great variety of tasks which, when performed by man, are usually associated with a definite level of insight and other attributes

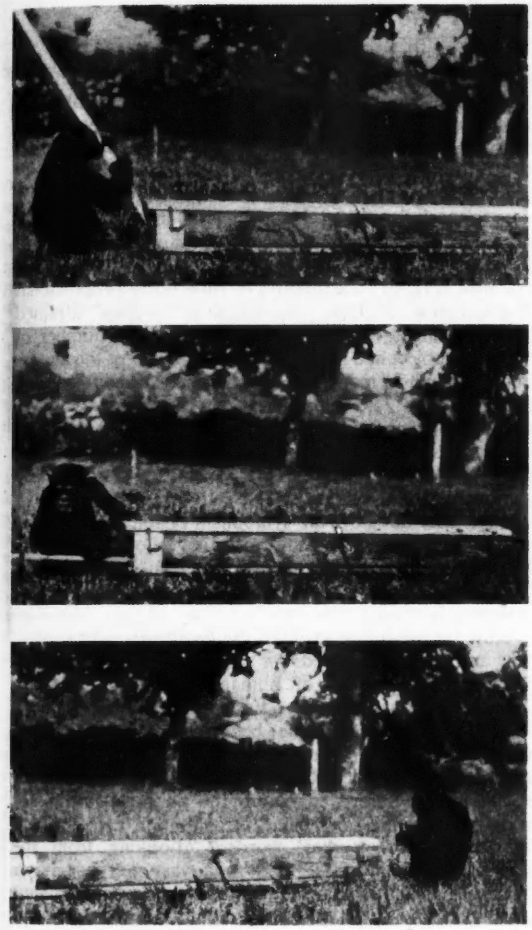

FIG. 4.—A young female chimpanzee solving the "Box-and-Pole" problem.

of mental intelligence. How far the ability of the chimpanzee to "learn" provides evidence of real intelligence, or how far it represents the performance of a series of events quite meaningless to the animal is a question by no means easy to answer. The effects of "concentration" and of reward on the speed and accuracy of learning are so similar to those observed in man that it is difficult to resist the conclusion that the underlying processes have a great deal in common; on the other hand, there is no evidence to suggest that a chimpanzee, when presented with a problem, attacks it by an organised type of procedure—the animal's behaviour is on nearly every occasion an exhibition of haphazard trial and error—initial success being reached by chance. Once the solution has been found, the number of errors made in subsequent tests progressively decreases. The interpretation of this fact is difficult; it may indicate little more than the establishment of a habit whereby the animal performs a series of relatively meaningless acts or, if the curve of errors falls abruptly, it may mean that the problem has been "mastered" in the sense that the animal has appreciated the significance of its acts by a process akin to insight. On this fundamental point the facts are as yet inconclusive.

Mental Tests for Chimpanzees

The nature of the problems presented to chimpanzees are relatively complex, and some of the most interesting are those comparable to the tests used for the assessment of mental processes in man. As a test of memory a number of boxes were arranged in a circle (Fig. 3), each box being identical in form and colour with one of its immediate neighbours but differing from all the others; the animal was stationed in the centre of the circle and into one member (right or left at random) of each pair of boxes was placed a "reward". The animal was then allowed to open the boxes. Using sixteen pairs of boxes the percentage of "successes" scored by two chimpanzees was 78, whereas the average score of four children was 63. It is difficult to avoid the conclusion that chimpanzees and man do not differ markedly in respect to their powers of observation and memory. On the other hand, the animal compares very unfavourably with man when confronted with a problem involving insight. For example, a long narrow box with open ends (Fig. 4) was securely fastened to the ground; at a distance of about 2 metres from the box was placed a pole equal in length to the box. The animal was then allowed to watch the observer place a banana in the centre of the box; the only way in which the chimpan-

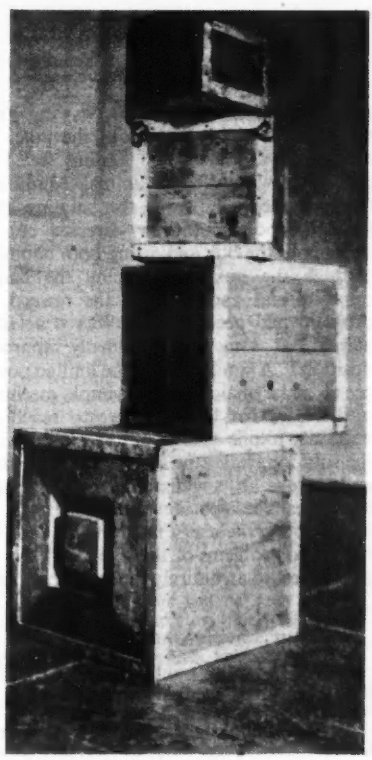

FIG. 5.—Box test for chimpanzee intelligence. The reward could only be reached by climbing to the top of the pile.

FIG. 6.—The chimpanzee is about to drop a token into the slot to "purchase" food.

zee could reach the banana was by pushing the latter through the box by means of the pole. For twelve successive days, trials—each lasting for 15 minutes—were performed with a female animal (Mamo) without success. Quite suddenly however the solution was reached—she lifted the pole in the air, directed one end toward the opening of the box and, using both hands, pushed the pole through the box thus forcing the banana out at the opposite end and securing the reward of success. The problem had been solved. Was it accidental or did the animal, at long last, suddenly appreciate the whole position? A similar test of the limited power of a chimpanzee to make unaided use of simple mechanical implements is illustrated in Fig. 5, where to reach a reward it was necessary to pile a series of boxes one on the other—again, the solution eludes the animal for surprisingly long periods and there is little evidence to suggest that the chimpanzee associates the special relationship of the boxes with ability to use them as a means to an end. It is, probably, in respect to problems of this type that the mind of man has progressed to an entirely different level to that of the ape.

Sounds and Symbols

Like all other types of vertebrates the chimpanzee can associate sounds with the immanence of other events. The sound of a gong becomes the sign or symbol of an approaching meal. Perhaps the most remarkable evidence of symbolic values is that which shows that the animals can respond to tokens as symbols of reward. In a well-planned experiment, Wolfe succeeded in training chimpanzees to work for poker chips which, at the end of a series of tests, could be exchanged by the animal for food—provided it placed them one by one in an automatic machine (Fig. 6)—the amount of food being proportional to the number of chips. The degree of "success" attained by the animals was truly remarkable. "The number of tokens a subject had in its possession was one of the factors determining how many tokens would be worked for during a fixed period . . . the more tokens possessed the fewer additional tokens would the subjects work to secure." Of two tokens the one which had twice the reward value of the other was preferentially selected. Quite clearly symbolic values can be established in the mind of the chimpanzee, but how far symbolism enables one animal to communicate effectively with its fellows—either as language or bodily gestures—is doubtful. If any such "language" exists, it must differ very greatly from our own.

How far the future study of the great apes may suggest new and effective methods for eliciting and preserving the more beneficial traits of human character we cannot foretell. This aspect of Dr. Yerkes' work is as yet in its infancy; nevertheless, the behaviour patterns of the chimpanzee and of man have sufficient in common to make it at least doubtful how far students of human sociology can afford to ignore the findings of psycho-biology. For the time being the situation can be summarized in Dr. Yerkes' words: "Looking from the chimpanzee man-wards, there is a vast gulf which we bridge with difficulty and reluctantly because of our assumed superiority to all living things. Really significant differences in sense or receptivity between ape and man have not been discovered. There are obvious perceptual dissimilarities which we generally interpret as favourable to us . . . but it is not an understatement to say that the ape is at the beginning of a road on which man has advanced far, although slowly and haltingly. In all the important aspects of life, our stage of development is immeasurably in advance of that of the chimpanzee. Yet we look to it hopefully when in search of origins and early phases of evolution and developmental progress. It is a reasonable hope that the psycho-biologist, sociologist and educator may discover in the great apes sources of unexpected enlightenment". From this and other points of view Dr. Yerkes' work represents an important and courageous step along the path of human inquiry.

Science Books for Prisoners of War

READERS of this magazine are invited to send any science books they can spare to the Prisoners of War Department (Educational Books), British Red Cross Society, New Bodleian, Oxford, from where they will be forwarded to prisoners of war who are reading science. A pamphlet giving an outline of the types of books required on science and other subjects may be obtained from the address given.

The Bookshelf

Systematics and the Origin of Species. By Ernst Mayr. (Columbia University Press, New York and O.U.P. London, 1942; pp. xiv + 334, with diagrams; 26*s.* 6*d.*).

DR. MAYR'S book is a major contribution to the literature of evolution. It is a most welcome product of the trend which has been noticeable in recent years towards a synthesis of the results of different disciplines in biology—systematics, genetics, ecology, and so on—which had previously tended all too much to isolation from one another. Dr. Julian Huxley's *Evolution* was symptomatic of the same trend, and the two works cover in part the same field, but the two are essentially different, though in a way complementary.

Mayr is less concerned than Huxley with the more general aspects of evolution and more expressly with one particular part of the field, albeit an absolutely basic one in any general consideration of the subject. His book is in fact a masterly treatment of the problem of how species originate, from the standpoint of a modern systematist, and it may be doubted whether anyone combines so effectively as Dr. Mayr the qualifications requisite for writing such a work. The reasons are not far to seek. In the first place, there is little doubt that birds are better known taxonomically than any other group of animals, so that an unparallelled wealth of material is available for analysis to the ornithological systematist, and in the second Dr. Mayr is at once the leading authority on the birds of Oceania and Indonesia, a part of the world of especial importance in the study of speciation, and a systematist who has a quite outstanding grasp of other relevant branches of biology, as well as of taxonomic work outside his own special field.

While the student of organic evolution in general must naturally take account of both animal and plant kingdoms, it appears to the reviewer definitely an advantage in the present case that the author frankly confines himself to the former. The factors involved in the evolution of species in plants and animals are by no means identical and the situation in plants is in some ways more complex. By confining attention to animals the issue is appreciably simplified and we gain a clearer picture of that part of the field. To say this is not to suggest that the problems involved are not quite sufficiently complex or to make light of the many questions to which as yet no adequate answer can be given. Nevertheless the picture which Dr. Mayr is able to present is in broad outline remarkably clear and convincing and we think that the reaction of many biologists after reading the book will be one of some surprise that material already to hand should be capable of yielding so much to a critical analysis.

As an ornithologist the author naturally draws primarily on birds—and particularly on his own special field of the East Indian and Pacific islands—for the bulk of the data which he discusses so illuminatingly, but the approach is throughout that of a general biologist, and many other groups than birds yield important evidence in the course of the discussion.

Dr. Mayr stresses at the outset the deep significance of the change in modern times from the static species concept of Linnaeus to the dynamic one of the species as an evolving entity tending to differentiate into a number of racial forms or subspecies in different parts of its range. These racial forms are the raw material from which new species originate, and the outstanding contribution of Dr. Mayr's book to evolutionary biology is the convincing demonstration that in the higher animals, apart from the quite special situation provided by the biological races of some parasites and plant-eating insects, all speciation is the product of geographical isolation of a population from its parent species, with the acquisition during the period of isolation of "characters which promote or guarantee reproductive isolation when the external barriers break down". In his conclusion that other sorts of isolation, such as ecological or genetic, are not effective in this way, Mayr's conclusions differ from those originally reached by Huxley, who, however, has handsomely admitted in a review in *Nature* that Mayr's evidence has led him to change his views.

It is important to note that the archipelagoes of the Pacific, in which the geographical isolation of areas is so much more general and clear-cut than in large continental areas like the Holarctic region, provide a peculiarly favourable situation for the study of speciation and it is obvious that Mayr's great experience of the birds of this region has contributed enormously to the clarity and convincingness of his analysis. It may be added that not the least interesting point in the book is the exposition of the peculiar conditions prevailing in Europe as a result of the relatively recent ice-age, in consequence of which conclusions about speciation based only or primarily on the fauna of this region are liable to be misleading.

For the rest it can only be said in such a necessarily brief notice that Dr. Mayr is equally illuminating on the other topics which figure in his book, such as the methods and principles of systematics, the nature of taxonomic characters and the systematic categories above the species. His work is bound to remain the standard authority on the subject for a number of years and will provide the essential foundation for future advances. It may be added in conclusion that although the subject is necessarily not a simple one the book is much easier and more lucid reading than some other related studies have been. B. W. TUCKER

Meteorology for the Airman. By James Paton (University of London Press; pp. 124 + 31 ill.; 3*s.* 6*d.*).

THIS little book is intended as a help to ATC and RAF cadets in their examinations. It can hardly claim to serve as a textbook of meteorology. While it fulfills its purpose to act as a supplement to or rather a summary of the usual course of meteorology lectures given to cadets, it is too condensed to serve as an introduction to meteorology for the general reader.

The book will be of considerable use to the air-cadets. The main outline of the meteorology course is summarised in a number of short chapters and the more difficult points are explained by good diagrammatical illustrations. There are also some excellent plates of cloud formations. The future airman will, however, do well to assume that the matter provided in the book represents rather the minimum than the maximum of meteorological knowledge required. K.M.

Prehistoric Britain. By Jacquetta and Christopher Hawkes. (Pelican Books; pp. 134 + 25 plates and 20 figs.; 9*d.*).

THE authors are both distinguished representatives of the modern scientific school of prehistory, and this may account for the dismissal of the somewhat nebulous half-million years of early progress—Eolithic, Pre-Paleolithic, Paleolithic and Mesolithic—in a single short chapter. The Sub-Crag industries are not mentioned; the "Abbevillian" hand-axe is clearly Acheulian; the first implements were more probably of wood or bone than of stone; the bow may have preceded the spear-thrower as "the first known instance of the use of a mechanical principle for supplementing mere man power". However, with the coming of the Neolithic the writers have woven from the confused and tangled skeins of cultural borrowings and invasions "from Spain and the Mediterranean, from Northern France, the Low Countries and Scandinavia" a vivid and convincing tapestry of man's past, a picture that will be welcomed by experts no less than by novices. The plates are well chosen, the facts beyond question, and the English lucid and alive—"One of the loveliest individual masterpieces of the early designers is the sword dredged from the river Witham. The bronze scabbard-mount curls up and over in curves as free and unpredictable as a sea wave." Mrs. Hawkes is particularly happy in the deft and apposite allusions to the influence on the progress towards civilization of the nimble fingers and delicate fancy of the women. The story has been illuminated by constant reference to modern analogies, to survivals, and even to recent events—Hitler's threat of invasion by the old historic routes. The volume is a credit to the authors and to the Pelican series. J. E. SAINTY.

SIR LAWRENCE BRAGG—*con. from* 103

During this war he has been very busy. At the Cavendish Laboratory he has had to plan courses for twice the normal number of students, owing to the influx of service cadets taking radio and radio-location courses. In the spring of 1941 he went to Canada as scientific liaison officer between that country and Britain. In the previous year Sir Henry Tizard had led a scientific mission to the U.S.A. and Canada for the purpose of improving the integration of the scientific war effort of Britain, the United States and Canada. As one American wrote, "This mission created more goodwill, and was more influential in enlisting the co-operation of American men of science than any other single event of recent years." Bragg stayed in Canada for six months, visiting various research centres in Canada and the U.S.A., and to him as well as to all the other scientists who preceded him and succeeded him we owe a debt of gratitude for having helped to introduce the personal touch into Allied scientific relations. There had previously been a great deal of difficulty in exchanging scientific information across the Atlantic—indeed A. V. Hill has gone so far as to say that the speed of travel of scientific intelligence was as low as 4½ miles an hour—presumably the speed of the slowest cargo boat sailing in convoy! Bragg and his colleagues realised that it would be faster to exchange scientists than it would be to rely on memoranda.

An incident that occurred during the development of the explosive RDX illustrates the advantages of the scheme Tizard, Bragg and others worked out. A group of Canadian chemists striving to get this explosive into large scale production made RDX by a radically new process. It was not certain however that the samples they had produced were identical with the explosive as perfected in Britain. So two of the Canadians, together with their samples of RDX, were flown to this country where they were able to satisfy themselves of the quality of the material they had prepared. As a result, little time was lost in getting this munition of war into industrial production.

Another useful mission which Bragg has made during the war was of a more cultural nature. In the spring of last year he visited Sweden on behalf of the British Council, visiting a number of towns and lecturing on his own special subjects. While there he visited Westgren who, following in the footsteps of the Braggs, has been responsible for a series of classic X-ray investigations on the structure of alloys, and the two scientists were able to initiate a scheme for collaboration between Britain and Sweden in the X-ray analysis field.

Bragg is distinguished both for his original researches and for his teaching. The worth of his researches have been recognised by the award of the Nobel Prize, the Barnard Prize and the Hughes Medal of the Royal Society. The excellence of his teaching can be judged from the calibre of his pupils, of whom A. J. Bradley, E. J. Williams, J. T. Randall and W. H. Taylor are among the most active.

At the present time he holds the presidency of the Institute of Physics. He has taken a great interest in the affairs of the committee which the Institute recently set up to watch and advise on matters affecting physics and physicists, and has studied very closely the problems of education and training; the lecture he gave on the latter subject in 1942 (*Nature*, **150**, p. 75) is well worth reading, and it is from that address that my opening quotation is taken.

He has a remarkable grasp of the research needs of British industry, and his advice on many aspects of applied physics is widely sought. At the end of 1942 he was elected to the Advisory Council of the D.S.I.R., and he represents that body on the Council of the Gas Research Board and the Cast Iron Research Association. He has also been its representative on the Wool and the Refractories Research Associations.

Sir Lawrence's views are often encouragingly optimistic, and his optimism is all the more infectious because it is based upon information rather than sentiment. The word "research" has been dripping altogether too glibly from too many lips of late, and some of its advocates have debased its meaning by talking about it instead of sponsoring it. I wish these gentlemen could be presented with a bound collection of Sir Lawrence's speeches, for they would then see that a sincere supporter of industrial research is also one of the keenest critics of present practices which spoil that branch of science.

Far and Near

Plants on Bomb Sites

MANY people have been impressed by the vegetation which has become general on most of the bombed scarred sites in London, in fact, there is one instance of a bombed site being clothed with red poppies, white chamomile daisies and blue lupins. Main interest is centred, however, on wild flowers and how they came to grow on the sites, and in a lecture on "Wild flowers of War-time London," illustrated by lantern slides, at the Birkbeck College, London, Dr. E. J. Salisbury, C.B.E., F.R.S., Director of the Royal Botanic Gardens, Kew, discussed how the plants reached these sites. The majority of the seeds of these wild flowers found were, he said, wind-borne.

Dr. Salisbury pointed out that after the Great Fire of London in 1666, the plant known as London Cress or London Rocket (*Sisymbrium Irio*) sprang up everywhere; it had since gradually died out, and he had not found a single plant on any of the bombed sites he had examined.

The most abundant plant—found on almost all bombed sites—was the Rose Bay Willow Herb *Epilobium angustifolium*) while next on the list came Coltsfoot (*Tussilago farfara*). Other plants included the Thorn Apple (*Datura stramonium*) which he had found on a site not far from Whitehall (the seeds of this plant have been known to lie dormant for 50 years); Sticky Groundsel (*Senecio viscosus*) a native of the Mediterranean first introduced into Britain in the Island of Ely in 1660; Oxford Ragwort (*Senecio squalidus*) Canadian Fleabane (*Erigeron canadensis*); and Gallant Soldiers (*Galinsoga parviflora*), an escape from Kew Gardens. The only garden plant occurring in great frequency on the bombed sites, the seeds of which were wind-borne, was the Purple Buddleia.

Certain seeds were carried to the sites—on people's feet or by other human agency—and these included Chickweed (*Stellaria media*); Rayless Mayweed or Pineapple Weed (*Matricaria suaveolena*), a native of America, now widespread in this country since the use of motor-cars and probably spread by being carried on the tyres; and species of the Shepherd's Purse (*Capsella Bursa-pastoris*).

Another means of seed dispersal was on clothing—a brushing from a man's trousers after a country walk, revealing seeds of grass, sórrel, plantain, groundsel, etc. Thanet Cress and some species of European grass found on the sites had probably come from hay used for horses.

The number of species of plants found on these sites, according to Dr. Salisbury, is very large. He instanced one small area, St. James' Church nave, Piccadilly, where he had found as many as 40. This showed the efficiency of seed dispersal.

Canada and Post-war 'Supply'

AN impressive view of Canada's potentialities as a world source of supply is given by Professor J. K. Robertson in "Canada's future in Test-Tubes?" (*Behind the Head-lines*, Vol. III, No. 8). In discussing the question how the scientist may contribute to the solution of post-war problems he surveys fields in which an improved technique may be expected not merely to intensify production in sources of supply already tapped, but also to develop such resources as are as yet touched barely if at all. In agriculture, for example, it is pointed out how great an advance has been made in the production of materials by synthesis as a basis for a supply of yarns, wool, and silks; in the use of wheat for the manufacture of alcohol which provides the raw material for the production of butadiene and synthetic rubber, while the casein from skim milk in one factory alone in Connecticut provides approximately 1,000,000 lb. a month of a textile which is an important constituent in cotton and rayon fabrics, while its uses in plastics seem to be unlimited. The wild life resources of Canada, already producing $20,000,000, are capable of still further development, and it still remains to be seen whether the all-important question of power cannot be determined in post-war planning in such a manner as to make available to industry Canada's vast amounts of water power. In mineral resources, Canada has a supply of coal alone which 1,000 years would not

exhaust, and which affords enormous possibilities in the development of satelite industries; and the possibilities of the supply of light metal still remain to be explored.

Professor Robertson points out that this survey of the possibilities of Canadian sources of supply regards the scientist only as technician—at the moment the sole view present to the public mind—but this does not exhaust either his capability or his duty in contributing to post-war planning. He argues, and with justice, that in all post-war problems—national and international—it is the duty of the man of science as a citizen to urge at all times the vital necessity for the scientific spirit and scientific method in the approach to the consideration of all problems of reconstruction, not merely the technological, but the economic and social as well.

Allied Lecturers in Great Britain

The Association of University Professors and Lecturers of the Allied Countries in Great Britain, of which the aim is to foster close contacts and cement international unity, has inaugurated a periodical publication as a "communication" to its members, in which they will be advised of the activities of the Association and informed of recent and current events. The first issue of this publication, which it is evidently intended should be known familiarly by the short title *Communication*, publishes a list of new members, items of personal interest and student news, and news from occupied countries.

In connection with the last named, it is of interest to note that in Switzerland, where there are 15,000 Polish internees, provision has been made for their needs in higher education by centres at the high school at Werzikon and the University centres at Fribourg, Herisau and Winterthur. To promote understanding of British methods among our guests an account of the organisation of the University Grants Committee is given by Sir Walter Moberly, its Chairman, and Mr. Oliver Bell describes visual methods in British Universities which shows the retent to which films are being used in the teaching of science, geography, history, and even, as an experiment, in economics and higher mathematics.

Among the Association's recent activities most attention is given here to the problem of the health of university students. It urges the institution in all universities of a compulsory contributory scheme for the treatment of illness such as those now in operation at Bale, Munich, and Aberystwyth.

Communication No. 2 appeared as we were about to go to press. It contains a useful historical summary of the Association's activities since it was formed, and gives further news of its members.

War-time Exhibits in Museums

A.R.P. and a much-depleted staff have curtailed sadly the activities of our museums. Nevertheless many of them, and notably the National Museums, have taken advantage of the space which has been released by the storage for safe-keeping of the more valuable exhibits to stage series illustrating or explaining topics of the moment under discussion among the general public—an important function of the museum at any time, but one frequently overlooked in the normal conditions of museum display. An example of how far it is possible for a museum to help the non-technically trained visitor towards an intelligent understanding of the conditions and bearings even of war-time problems is afforded by the series of exhibits shown by the Welsh museums, of which some particulars are given in the 36th Annual Report of the National Museum of Wales covering the year 1941-2.

An important decision affecting Treasure Trove within the borders of Wales is recorded in the Report. In response to a question in Parliament the Chancellor of the Exchequer has stated that in future instead of Welsh "finds" going to the British Museum as hitherto they will be brought, after their first examination by the authorities of that Museum, to the notice of the National Museum of Wales which is to have the right of pre-emption.

The *Glasgow Herald* records the opening of an exhibition of Scottish animals and birds, beautifully mounted and arranged by the Natural History Department of the Royal Scottish Museum, Chambers Street, Edinburgh, in the main hall of the Museum. It consists of exhibits which have been in storage since the outbreak of war and of others recently acquired.

Linnean Society New Pamphlet

The Linnean Society has now published the first pamphlet of a series of Synopses of the British Fauna (price 1*s*.). It is written by Theodore H. Savory and deals with the Opiliones (Harvestmen). The descriptions of the 20 British species and the key will be invaluable to naturalists interested in this group of arachnids.

Personal Notes

Professor F. A. E. Crew, who has occupied the chair of Animal Genetics at Edinburgh since 1928, has been appointed to the Bruce and Usher Chair of Public Health at that University. The appointment is to be regarded as marking a significant development in Edinburgh's medical teaching and research. Professor Crew is at present serving in the Army Medical Service with the rank of brigadier, and is acting as director of biological research at the War Office.

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In a lecture to the Royal Society of Arts recently, the director of the Geological Survey of Great Britain, Dr. E. B. Bailey, revealed that during the siege of Malta he was flown to that island to look for additional water supplies. "It was following on the famous fight to reach the island made by the great convoy", he said. "The question was whether, by increasing local water supplies, they could keep down imports of food and use the water for irrigation. We got the water, but I have not had further reports on it."

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Mr. R. S. Glover has been appointed temporary, research biologist at University College, Hull, in place of Dr. H. G. Stubbings, who has been granted leave of absence for work of national importance.

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In connection with the development of food dehydration in this country during the war, the Ministry of Food has announced the names of two of the scientists responsible for progress in this field of technology. The first is Dr. J. Barker, senior scientific adviser to the Dehydration Division of the Ministry, and formerly one of the senior scientific officers at the Low Temperature Research Station, Cambridge. The other is Dr. A. W. Scott, a lecturer in the Engineering and Applied Mechanics Department of the Royal Technical College, Glasgow.

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For the first time in the history of the West of Scotland Agricultural College a woman student, Miss Margaret B. Millar, won the prize in agricultural engineering and surveying that is offered for the most successful final year student.

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Dr. R. E. Stradling has been appointed to the newly created position of Chief Scientific Adviser in the Ministry of Works. Dr. Stradling will retain his post of Chief Adviser in Research and Experiments in the Ministry of Home Security.

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The Medical Research Council has established a unit for research in human nutrition, with Dr. B. S. Platt as its director.

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Dr. Alwyn Douglas Crow, 49 year-old ballistics expert, has been named as head of the team of workers responsible for developing the A.A. rocket gun, known for a long time as the "Z weapon". It was in 1936 that Dr. Crow was instructed to get together a team of chemists, physicists, ballistics experts, and engineers to explore the possibilities of the rocket gun. By the time of Munich a prototype that promised every chance of success had been produced. It was not however until April 1941, after continuous experimentation and repeated improvement, that Dr. Crow and his team of experts were satisfied with the results and the first gun went into action. At one stage of development the weather in Britain became so unsuitable for accurate observation of the flight of the rockets that the weapon had to be taken to Jamaica for further trials. The guns now form a vital part in the air defence of Great Britain. No claims are made as to its accuracy, the rocket gun being a weapon that depends for its effect on concentration. The specific range of the rocket projectiles is still a secret, but they have destroyed many bombers at average heights.

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Dr. E. F. Armstrong, F.R.S. has been elected chairman of the commission set up by the Conference of Allied Ministers of Education to report on the problems involved in the supply of scientific

equipment to the occupied countries after their liberation.

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PROFESSOR H. W. PEARSALL, professor of botany at Sheffield, has been appointed Quain Professor of Botany in University College, London, in succession to Professor E. J. Salisbury, who is now director of Kew Gardens.

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DR. OTTO STRUVE, director of the Yerkes and the McDonald Observatories, has been awarded the Gold Medal of the Royal Astronomical Society for his work on the observation and interpretation of the spectra of stars and nebulæ.

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SIR DAVID PRAIN, F.R.S., director of Kew Gardens for 17 years, died on March 16. After graduating at Aberdeen with honours in science he became a schoolmaster at Ramsgate College. Two years later he proceeded to Edinburgh University where he studied medicine, taking his M.B. in 1883. From there he went to India as a member of the Indian Medical Service. For a time he was attached to native regiments in different parts of India. Then he was chosen for the post of curator of the herbarium at the Royal Botanic Garden at Calcutta. He spent 11 years as curator and then succeeded the late Sir George King as superintendent of the garden. His next post was that of director of the Botanical Survey of India. He was appointed director of Kew in 1905. He published in 1903 a book about the plants of Bengal, and for the 13 years from 1907 he edited the *Botanical Magazine*. Among other posts he held was the treasurership of the Royal Society (he was elected an F.R.S. in 1919) and directorship of the Forest Products Research Board of the D.S.I.R.

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PROFESSOR ARTHUR ERNEST JOLLIFFE, Emeritus Professor of Mathematics, King's College, London, since 1936, died at his home in Oxford on March 17 at the age of 73.

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Plastics on Railways

THE Southern Railway has just put into operation the first plastic passenger luggage vans. The new van weighs only four-fifths as much as vans of the ordinary 13-ton type, and has cushioning between the underframe and the body which absorbs shocks when travelling or being shunted.

Dried Foodstuffs

As a method of preserving, the value of drying is fairly obvious; nature uses the method for seeds, said Dr. Franklin Kidd, M.A., D.Sc., superintendent of the Low Temperature Research Station, Cambridge, when giving the first of his lectures on "Dehydration of Foodstuffs" at the Royal Society of Arts, London. Years ago, he said, the potato was dried in the Andes by the natives; sago and tapioca (dried starch) from the root and pith of the manioc plant were the products of native industries; while the North and South American Indians used to produce dried meat. Tracing the status of dried foods before 1939, he pointed out that between 1870 and the last war a great many efforts to use dried vegetables failed because it was not realised that it was essential to keep the vegetables in good condition after drying. Dried vegetables were used in the last war, but most of the products used were of inferior keeping quality; the impression left was a poor one. At the outbreak of the present war, attention was again directed to the possibilities of dehydrated foods because of the economies in transport that dehydration offered. Most of the work on dehydration had been done since this war started.

Referring to the dehydration of meat and eggs he instanced the reduced space required and quoted actual figures; for instance, a quarter of beef weighing 150 lb. was reduced to 112 lb. when boned, to 96 lb. when canned, and to 37 lb. when dried and canned. He also instanced the smaller space required when 360 eggs were dried compared with the 270 lb. of grain needed to produce them and a space of 6 cubic feet needed when eggs are packed in the ordinary way as shell eggs.

John Hadley's Bi-centenary

THIS year sees the 200th anniversary of the death of John Hadley, inventor of the sextant, one of the most important of the mariner's scientific instruments.

Hadley was born in 1682 and was the son of the High Sheriff of Hertfordshire. Even as a child he was very interested in practical mechanics and soon began to make improvements in the various optical instruments of his time. Three years after his election as a Fellow of the Royal Society he began work to improve the reflecting telescope. He constructed a metallic reflecting mirror 5 inches in diameter with a focal length of over 5 feet. Dr. Halley, the Astronomer Royal at the time, praised Hadley's instrument and extensive use was made of it. In 1728 Hadley was elected vice-president of the Council of the Royal Society. He died in 1744. John Hadley invented his sextant in 1730. It was an improvement upon an earlier instrument known as an octant, and underwent extensive tests by the Admiralty before its universal adoption.

Later in the same year as Hadley invented his sextant a Thomas Godfrey of Philadelphia, Pennsylvania produced a similiar instrument to Hadley's. The Englishman is, however, generally given credit for being the inventor of the sextant as he produced his discovery some months previous to Godfrey. It is believed that both men made their discoveries quite independently.

Feltmaking Research

THE Worshipful Company of Feltmakers of London have inaugurated a research movement in their industry in which it is hoped that all sections of the trade will participate. As a means of stimulating interest in research, the Feltmakers have offered for annual competition among scientists and research students a gold medal and diploma.

B.B.C's Talk on Research

A broadcast in the Home Service on March 20th in the "Question for To-day and To-morrow" series on Research in Industry was very forcefully performed. Dr. W. T. Astbury, F.R.S., reader in Textile Physics at Leeds, and Dr. J. B. Speakman, professor of Textile Industries at the same university, argued strongly the case for scientific research in industry with Mr. D. Hamilton and Mr. T. Marshall, a wool merchant and a woollen manufacturer respectively.

It is difficult to believe that Mr. Marshall was in earnest when saying, "I suppose it's reasonable to say that there are three types of research—pure research, applied research and strictly practical investigations of trade problems. Of these, I like the last best and the first least of all. It appears to me that in pure research there is no definite aim in view. In other words, the person doing the job in question sits down at a microscope and peers at a piece of fibre for months on end and finally comes to a certain conclusion by microscopic and chemical analysis that that fibre is built up of a particular molecular formation. This may be very interesting from a scientific point of view, but it leaves the man who has to transform fibres into cloth absolutely cold. Can anybody, justify pure research to the practical business man?" Well of course, the two scientists presented quite adequately the usual case for scientific research.

Although the broadcast was forceful, whether it told the listeners much about the link between science and industry is another matter. It is very doubtful if Messrs. Marshall and Hamilton went away from the studio with a changed mind—and if they didn't, it is obvious that the broadcast failed too with the public outside the studio. A different approach to this type of broadcast is urgently needed.

Botanical Bequest

BY the will of the late Professor J. H. W. Trail, Aberdeen University has received £500 to provide an annual prize for research in botany, and £500 to provide books and periodicals dealing with plant diseases and their treatment.

Tapping Wild Rubber in India

THE first "wild rubber" plantation of the Government of India is to come into production this year, it is reported. The rubber-bearing plant in this instance, is *Cryptostegia grandiflora*, or pulay, a climbing asclepiad. Seeds collected from all over India were planted last summer in 5000 acres at Muttra, near Delhi, and will produce a few hundred tons of rubber this year. No really economic method of extracting the rubber has yet been evolved, and serious competition with plantation rubber is not envisaged.

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THE DISPENSARY

THE part played by the British chemical industry in the discovery and preparation of healing drugs and specifics is fundamental. It is not perhaps as obvious. That is, people do not readily associate the soda bicarbonate they buy, or the sulphanilamides that the doctor prescribes, with the limestone, salt and coal which are the raw materials of the great chemical factories. The apothecaries of old made their extracts, decoctions and elixirs chiefly from vegetable substances. These were given to patients without any precise knowledge of what their effects would be. About a hundred and fifty years ago the science of pharmacology began to be developed. The pioneers tried out their discoveries on animals and even on themselves. This method of trial and error sometimes had painful results, and one of the fathers of the science, William Alexander of Edinburgh, nearly killed himself. Nowadays the research chemist, the pharmacologist and the medical practitioner work together to perfect new drugs with new effects and special properties. The great majority of these are organic compounds, many of them the result of research in the dyestuffs industry. Suramin, to give one example, a specific for African sleeping sickness, was discovered as a result of the biological examination of dyes related to Congo Red—one of the earliest synthetic dyes, which is still used for the bright garments of the East. Modern drugs are largely synthesised from coal tar, from which substances like benzene, toluene and naphthalene are first obtained. These are next modified and combined with other chemicals by the research chemist. There are few industrial chemicals produced today which are not used at some stage in the preparation of drugs. The chemical industry is the basis on which the British research chemist is building up a constantly increasing supply of new and better drugs.

Imperial Chemical Industries Limited, London, S.W.1

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